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A REVIEW OF 1994

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13. ABSTRACT *(Maximum 200 words)*

Success stories from 1994/95 that recognize the accomplishments and combined effort of Wright Laboratory scientists and engineers. Stories have been selected from the following categories: TECHNOLOGY TRANSITION -- Technology that has achieved application on a Department of Defense system in development or operation or that has provided "quick-reaction" response to problems or needs of field organizations; TECHNOLOGY TRANSFER -- Technology that has transferred from the laboratory to the private sector, to include: industry, academia, and state and local governments; TECHNICAL ACHIEVEMENT -- Major innovative technological advancements that offer significant potential for existing and future Air Force systems; and, PEER RECOGNITION -- External awards or recognitions by the scientific community at large.

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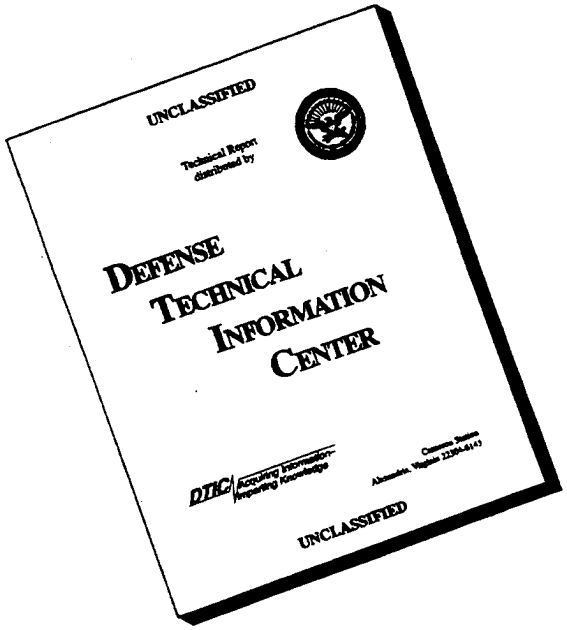

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WRIGHT LABORATORY
SUCCESS STORIES
A REVIEW OF 1994

Air Force
SCIENCE & TECHNOLOGY

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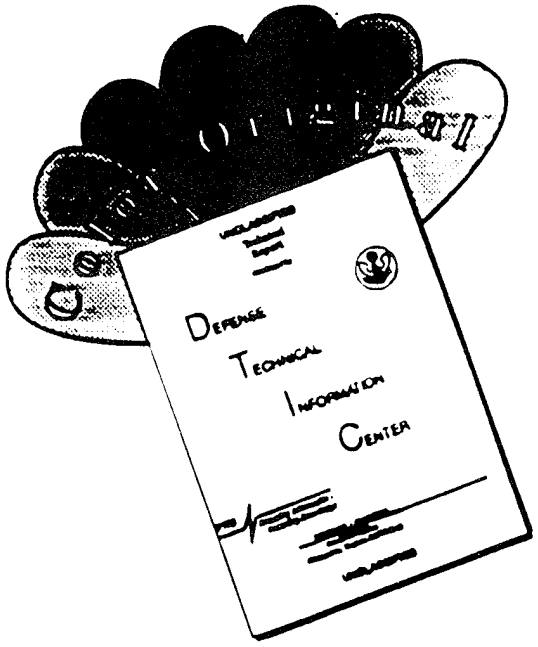

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A Message About Wright Laboratory Success Stories

Each year we highlight the best and brightest of our laboratory efforts with "Success Story" profiles. These brief profiles of ongoing research and development projects offer a snapshot look at the breadth and depth of ongoing work at the Air Force's Wright Laboratory. I invite you to explore the diverse, exciting and innovative work ongoing at Wright Laboratory during 1994-1995.

For more than 65 years, vital aerospace research and advanced technology developments in materials, avionics, engines, flight dynamics, solid state electronics and integrated manufacturing have been performed by Wright Laboratory. This work has enabled our Air Force to establish and maintain its acknowledged position as the world's most technically advanced and capable in the world.

In a rapidly changing Defense environment, a new challenge has been accepted by Wright Laboratory. That is to dramatically expand laboratory accessibility to the commercial marketplace, offering a rich and powerful resource to America's private sector. This expanded laboratory focus is viewed as critical to helping the country become more economically competitive. Our laboratory continues to selectively nurture the most promising array of aerospace technologies. Today these technologies are the ones that meet the needs of our fighting forces while also offering "dual-use" potential in the commercial sector.

Should you see a Wright Laboratory "Success Story" you want to know more about, I hope you will contact us so we might share the details.

David A. Herrelko
Colonel, USAF
Commander
Wright Laboratory

Wright Laboratory Success Stories

Table of Contents

(continued on next page...)

(continued on next page...)

Introduction

Over 280 Air Force Science and Technology "Success Stories" from the Air Force's Wright Laboratory have been presented over the past six years. The individual stories most often represent the combined effort of several scientists and engineers working as a team. The basic and applied research, plus the follow-on technology development described in a "Success Story," are viewed as essential to the continued success of the Wright Laboratory mission.

This year's "Success Stories" were selected from one or more of the following categories:

Technology Transition: Technology that has achieved application on a Department of Defense system in development or operation or that has provided "quick-reaction" response to problems or needs of field organizations (see Table I).

Technology Transfer: Technology that has transferred from the laboratory to the private sector, to include: industry, academia, and state and local governments (see Table II).

Technical Achievement: Major innovative technological advancements that offer significant potential for existing and future Air Force systems (see Table III).

Peer Recognition: External awards or recognitions by the scientific community at large, concerning technology advancements in the areas of Technology Transition, Technology Transfer or Technical Achievement (see Table IV).

To receive more information on the "Success Stories" contained in this document by the experts involved, or to learn about other activities at Wright Laboratory, please contact: WL/DOR, 2130 Eighth Street, Suite 1, Wright-Patterson AFB OH 45433-7542, Tel. (513) 255-4119 or fill-in, and send us the reply card located in the back of this brochure.

Table I. Technology Transition Success Stories

Table II. Technology Transfer Success Stories

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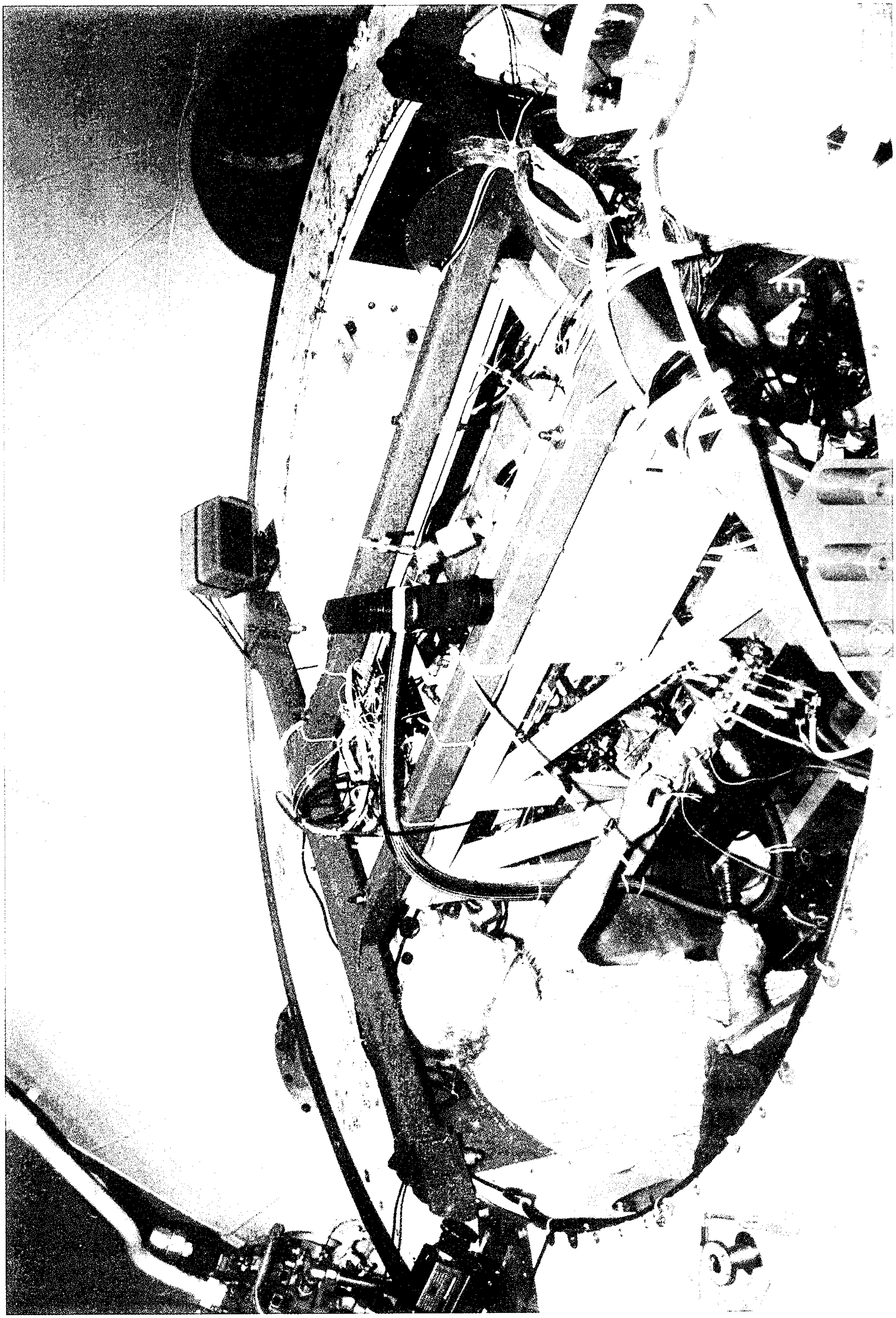
Table II. Technology Transfer Success Stories (Cont'd)

Table III. Technical Achievement Success Stories

Table III. Technical Achievement Success Stories (Cont'd)

Table IV. Peer Recognition Success Stories

1994 Wright Laboratory Success Stories



Integrated Closed Environmental Control System (ICECS)

Payoff

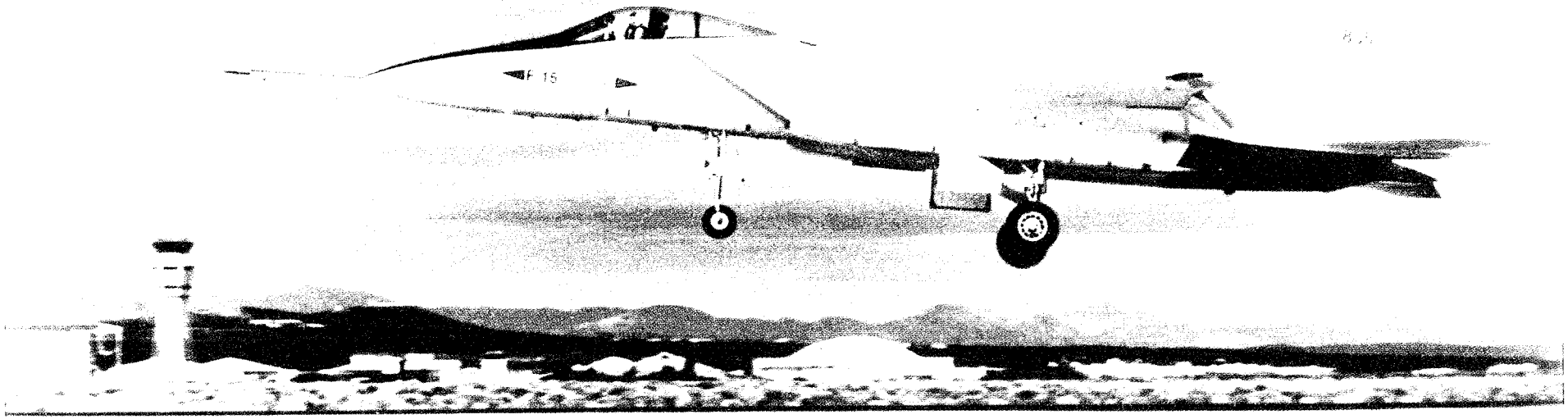
Life cycle cost (LCC) studies demonstrated that constant liquid cooling of avionics, using the basic ICECS (shown left, in a centrifuge) would save $23 million per year for a fleet of 150 operational aircraft like the F-15C flying 300 hr/yr/aircraft over 15 years. Centrifuge tests showed that an ICECS equivalent to an F-15 open air environmental control system (ECS) translates into an 8 percent reduction in take-off gross weight, or a 12 percent increase in range for a F-15 type aircraft. ICECS data will be used to support qualification of the F-22 aircraft liquid cooled avionics integrated ECS package.

Accomplishment

The Flight Dynamics Directorate's Vehicle Subsystems Division successfully demonstrated in a centrifuge facility a total aircraft vapor cycle ECS that can operate in a fighter type high gravity (up to 9g's) environment. The basic ICECS is designed for a fighter aircraft with advanced liquid cooled avionics.

Background

Present day military fighter aircraft use various state of the art open air cycle ECS schemes. However, open air cycle ECS packages require the use of large bleed and ram air flow rates; their control is susceptible to widely varying boundary conditions in high performance flight; and they incur weight, range and LCC penalties. These limitations and penalties prompted the Flight Dynamics Directorate and Industry, Science & Technology of Canada to team and jointly develop a digitally controlled breadboard closed loop vapor cycle ECS package to investigate performance benefits and determine the extent to which g-forces will affect ECS operations and efficiency. Simulated tests were designed to demonstrate and verify that the ICECS will properly operate in g-fields imposed by a fighter. Armstrong Laboratory's Dynamic Environment Simulator was selected for the centrifuge test. The Naval Air Warfare Center supplied ECS components and an electrically driven vapor cycle compressor. The tests of the vapor cycle system revealed design deficiencies of the hardware which were corrected. The hardware was successfully interfaced with the software to develop and verify the control system laws and operation. The tests also demonstrated the viability of using integrated digital controls and showed that the heat exchangers used can be designed with minimum effects from g-fields imposed by fighter aircraft. Allied Signal Aerospace Systems and Equipment will use the ICECS data to support qualification of the F-22 aircraft liquid cooled avionics integrated ECS package.


F 15

F-15 Lands With Locked Flight Controls

Payoff

The successful application of propulsion controlled aircraft technology to the F-15 provides an alternative approach for a backup system to safely land an aircraft that has experienced complete flight control system failure. This technology, coupled with other current digital and sensor technologies, offers the potential to recover future military or civilian aircraft without the loss of life.

Accomplishment

Under the Propulsion Controlled Aircraft (PCA) program, partially funded by the Flight Dynamics Directorate and managed by NASA Dryden, the F-15 Highly Integrated Digital Electronic Control (HIDEC) aircraft made a successful controlled landing at Edwards AFB CA, with all its flight control surfaces locked and using engine thrust only (no thrust vectoring) for control. This is believed to be the first controlled landing of an aircraft with all aerodynamic control surfaces inoperative.

Background

The original objective of the PCA program was to enable a pilot whose flight controls had been completely disabled over enemy territory to return to friendly territory and eject. It was proposed as a limited extension of a joint Air Force/NASA Self-Repairing Flight Control System Program that concluded in April 1990. The PCA program objective was expanded to include the possible landing of the F-15 HIDEC with locked flight controls. This decision was made following the July 1989 crash of a United Airlines DC-10 due to complete flight control surface lock and some preliminary thrust control analysis. Attempts to control the F-15 HIDEC through manual control of the throttles only, when it was level and trimmed out, was very difficult but possible. However, the aircraft could not be controlled with any precision. Even in the simulator (which handled better), a landing (not a crash) could be accomplished only occasionally by a highly skilled pilot. The control problems are caused by lightly damped Dutch roll and phugoid mode oscillations and the slow response of the engines to throttle changes. A computer program was written utilizing aircraft angle and rate information coupled with pilot commands to provide the fine control required to safely land the HIDEC with its flight controls locked. A HUD display showing the commanded flight path of the aircraft was provided to enable the pilot to immediately know the effect of his commands, thereby precluding over or under control of the aircraft. The HIDEC was controlled through pitch and roll thumbwheel rotary switches located behind the throttle quadrant. This system allowed consistently safe landing in the simulator. In-flight, the system performed well and after several low approaches to ever lower altitudes the aircraft was safely landed.

Digital High Resolution Real-Time Radiography System Improves Nondestructive Inspection

Payoff

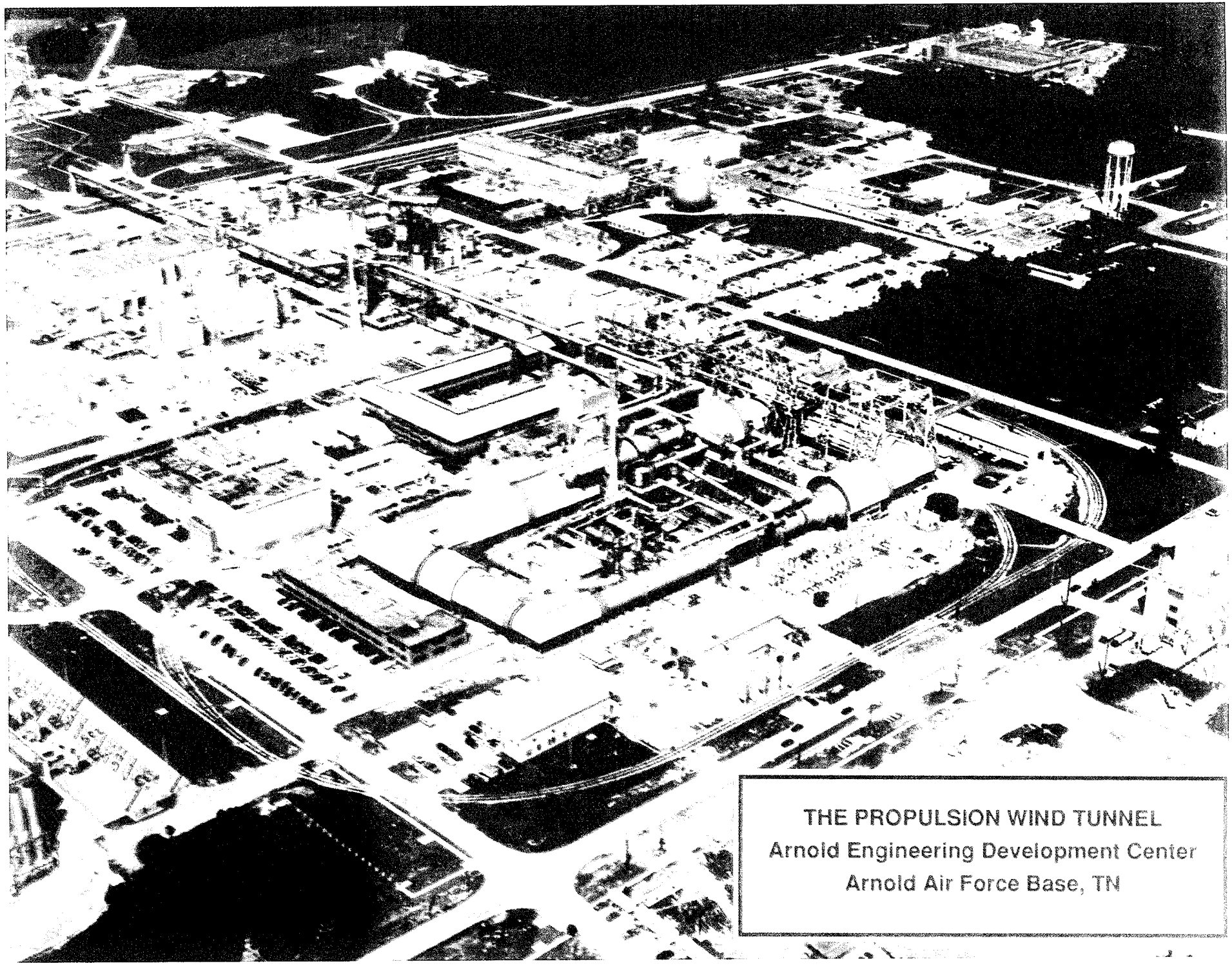
The digital High Resolution Real-Time Radiography (HRRTR) system will provide aircraft maintenance personnel a faster and simpler nondestructive inspection tool for evaluating corrosion, foreign object and severe fatigue damage in full-scale aircraft components. Replacing current real-time and film radiography systems with this new system could save the Air Force $25 million per year in nondestructive inspection costs while reducing the use of photographic chemicals and X-ray film. An interest in developing this technology for mammography has been expressed by the National Cancer Institute.

Accomplishment

Researchers at the Materials Directorate and Lockheed Missile and Space Company have developed a digital nondestructive evaluation system that can improve and simplify X-ray inspections of aircraft airframe and engine components. The new system is capable of 25 micron resolution and has a dynamic range about 10 times better than film systems.

Background

To meet increasing requirements for sustaining the aging Air Force aircraft fleet, accurate and efficient methods are necessary for detecting fatigue and corrosion damage. Air Force aircraft maintenance managers have identified the need to enhance their real-time nondestructive inspection capability for evaluating corrosion, cracks, and other service related damage to aircraft components. The Materials Directorate's Nondestructive Evaluation Branch was asked to develop a high spatial resolution, high contrast, digital system that could demonstrate a net improvement over currently used real-time and radiographic film systems. A preprototype of the HRRTR system was demonstrated at an Air Force nondestructive inspection managers meeting that included personnel from the Air Force's air logistics centers, major commands and Wright Laboratory. The advanced X-ray detector is based on a new high sensitivity glass composition which can be fabricated into high resolution coherent fiber-optic plates. These plates are then linked to a charge-coupled-device to produce an image of near photographic quality. A robotic manipulation capability will be added later, which will use a computer-aided design system to guide the incremental inspection of aircraft. The goal for the new system is a three to five second scan time for each interval.



THE PROPULSION WIND TUNNEL
Arnold Engineering Development Center
Arnold Air Force Base, TN

Fatigue Crack Growth Analysis Technique

Payoff

An application of the Flight Dynamics Directorate's fatigue crack growth prediction software (MODGRO) to determine whether aging Arnold Engineering Development Center (AEDC) wind tunnel compressor components should be repaired or replaced has resulted in a cost avoidance to the Air Force of over $4 million and avoided costly facility down time. MODGRO provides a comprehensive and unique capability to predict crack growth for a wide variety of structures and loading conditions and is now being used throughout the DOD, NASA, academia and industry.

Accomplishment

The Flight Dynamics Directorate's Structures Division successfully performed a structural life analysis of axial compressors used in the AEDC wind tunnels that resulted in a cost avoidance of over $4 million. The Directorate's in-house developed, fatigue crack growth prediction software (MODGRO) was used to determine whether the aging components of the compressor should have been repaired or replaced.

Background

AEDC facility wind tunnels are used for testing the effects of airflow over variously shaped aircraft, missiles, aerospace vehicles and their components under simulated flight conditions. Compressors used in these wind tunnels have served nearly 35 years of an originally scheduled 20-year design life. As a result, cracks have developed in both rotor body and shaft components threatening the multi-million dollar test facility's continued operation. The supplier of these compressors urged AEDC to replace the eight compressors at a cost of over $6 million. AEDC personnel instead contacted the Structures Division requesting assistance in evaluating the feasibility of repairing the components. Working with the Division, AEDC designed a repair which required machining out flaws and reducing areas of high stress concentration by increasing critical radii in the high pressure/temperature areas. Finite element analyses were conducted to determine the reduction in stress at the radii. The Division then performed extensive 2-D crack growth analyses (using MODGRO) on both original and repaired rotor body and shaft components to assess the likelihood of compressor failure. Results showed that repair of the rotor body would prove successful, but each shaft component would have to be replaced (at a cost of less than $2M). Based on this analysis, AEDC elected to implement the Directorate's recommendation of repair, rather than perform the complete replacement of the compressor as originally suggested by the compressor vendor. Following more than four months and hundreds of hours of extensive wind tunnel operation since implementing the recommendation, AEDC facility inspectors found no further cracking problems. As a result, AEDC has credited the Structures Division with a cost avoidance of over $4 million in emergency replacement costs.

The F-15 Advanced Windshield

Payoff

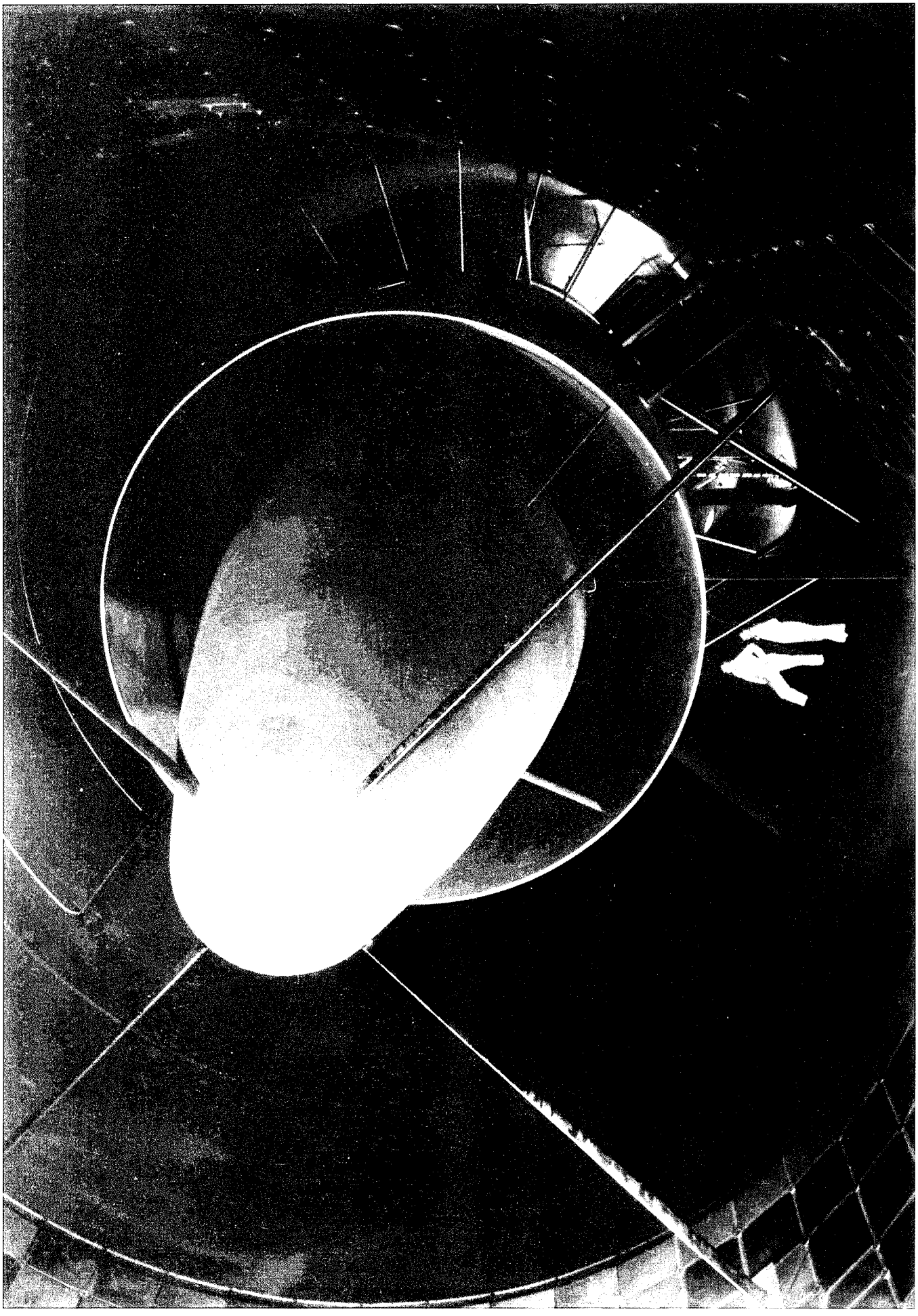
An F-15 Advanced Windshield is ready for introduction to the fleet as a preferred spare. Spares procurement with the windshield is projected to be 33 percent less costly than for the current windshield. Over the next 20 years, the F-15 aircraft will realize the benefit of mission-compatible birdstrike protection, less aircraft downtime and an estimated $77 million reduction in logistical costs.

Accomplishment

Technology that increases performance while reducing cost was incorporated into an F-15 windshield capable of withstanding a 4 pound birdstrike at 544 knots (the existing windshield has a 410 knot capability). Service testing has demonstrated interchangeability among all models and a reduction in change out time from 56 hours to 4 hours. Currently, the windshield has survived a period of more than half its service life goal.

Background

Working closely with the F-15 System Program Office, Warner-Robins Air Logistics Center, Headquarters Air Combat Command and McDonnell Douglas Aircraft Company, the Flight Dynamics Directorate investigated the capability of the current windshield and the requirements a future windshield would need to meet. This investigation resulted in design goals for the advanced windshield that included: 500 knot/4pound birdstrike protection, 4 year service life, 50 percent reduction in unit cost and a 4 hour change out. To bring these goals to reality, the expertise of other organizations was utilized. The University of Dayton Research Institute and Sierracin/Sylmar Corporation designed and fabricated a prototype for a number of technology demonstrations. Arnold Engineering Development Center enabled the expanding team to exceed the birdstrike goal with a successful 544 knot impact simulation. The 46th Test Wing provided the aircraft and technicians to demonstrate interchangeability and the 4 hour change out.



Quick Reaction Keeps F-22 And F/A-18 Aircraft Test Programs On Track

Payoff

Quick reaction by a team of engineers from the Materials Directorate to a fan blade cracking problem in the supersonic wind tunnel at Arnold Engineering and Development Center (AEDC) prevented delays in F-22 and F/A-18 aircraft test programs. Their analysis and repair solution saved the Department of Defense more than $800,000 and reduced the downtime required to find and fix the problem from eight months to less than four months.

Accomplishment

Within 45 days, a team of engineers from the Materials Directorate found the source of a wind tunnel fan blade cracking problem at AEDC and recommended inspection and repair procedures. Their in-depth failure analysis and investigation of the blades manufacturing procedures determined the cause of the failure to be improper machining techniques.

Background

The supersonic wind tunnel at AEDC, Arnold AFB TN, is critical to the Engineering and Manufacturing Development phase of the F-22 aircraft program and has also been instrumental for testing in the Navy's F/A-18 program. Cracks were discovered in some of that tunnel's fan blades which stopped all testing until the problem could be solved. To avoid a significant and costly delay in the F-22 development program, the wind tunnel needed to be back in operation as soon as possible. AEDC asked engineers in the Materials Directorate's Systems Support Division to analyze and solve the problem. A team consisting of specialists in failure analysis, corrosion control, nondestructive evaluation and materials testing was formed to support their request. A fast, reliable inspection method was developed using eddy current and ultrasonic techniques to detect and measure the small cracks in the tight, complex curvatures of the blade assembly. A mechanical paint removal technique called plastic media blasting was recommended, as a necessary precursor to intermediate level nondestructive evaluation and weld repair processes. Quality procedures were provided to AEDC to eliminate high stress areas in finished assemblies. The Materials Directorate team also provided a comprehensive weld repair procedure and tested the weld repair recommendation to confirm that the life built into the repair was adequate for the service life of each fan blade.

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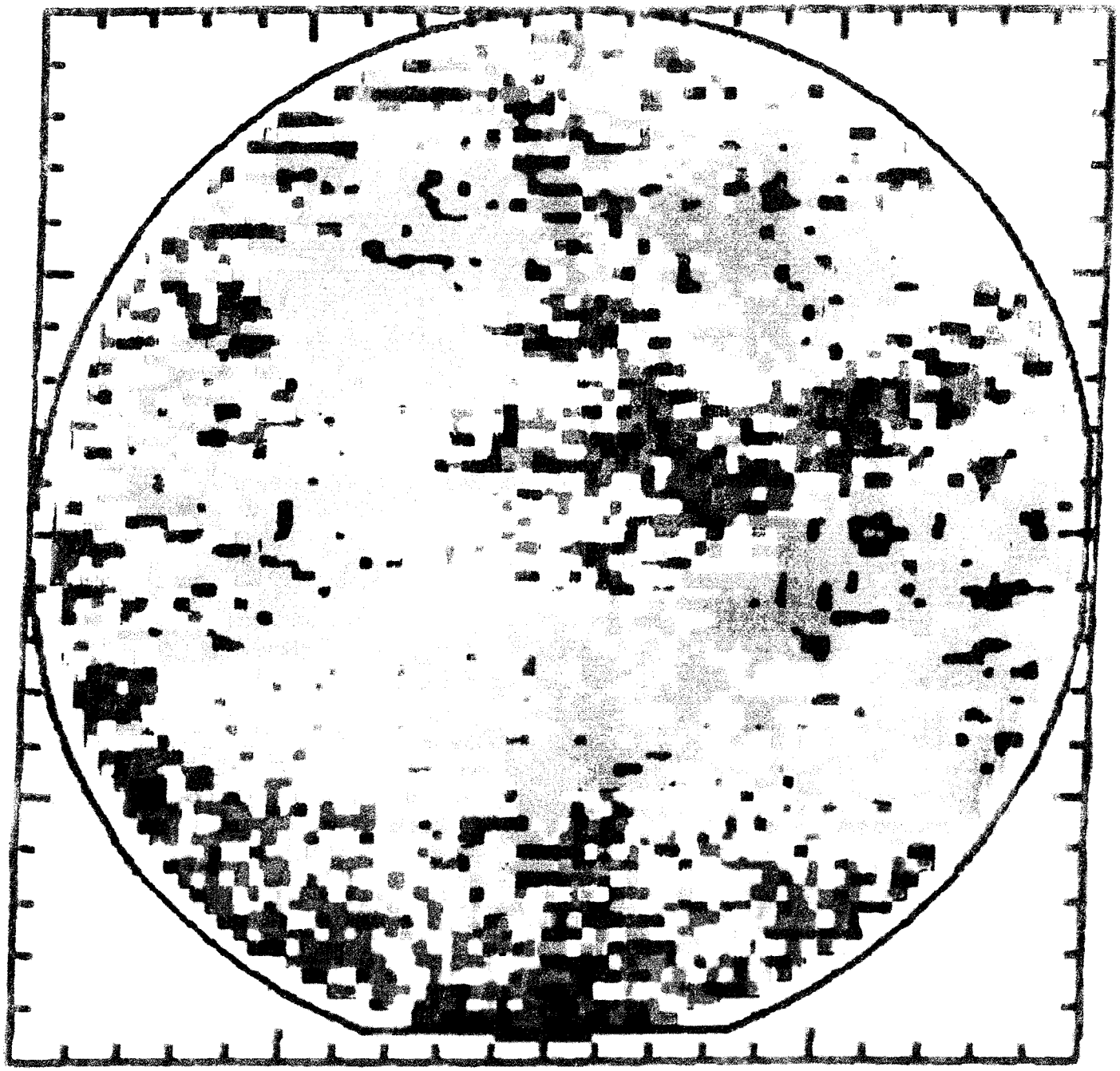


Cooperative Research And Development Agreement (CRDA) With Crystal Specialties International

Payoff

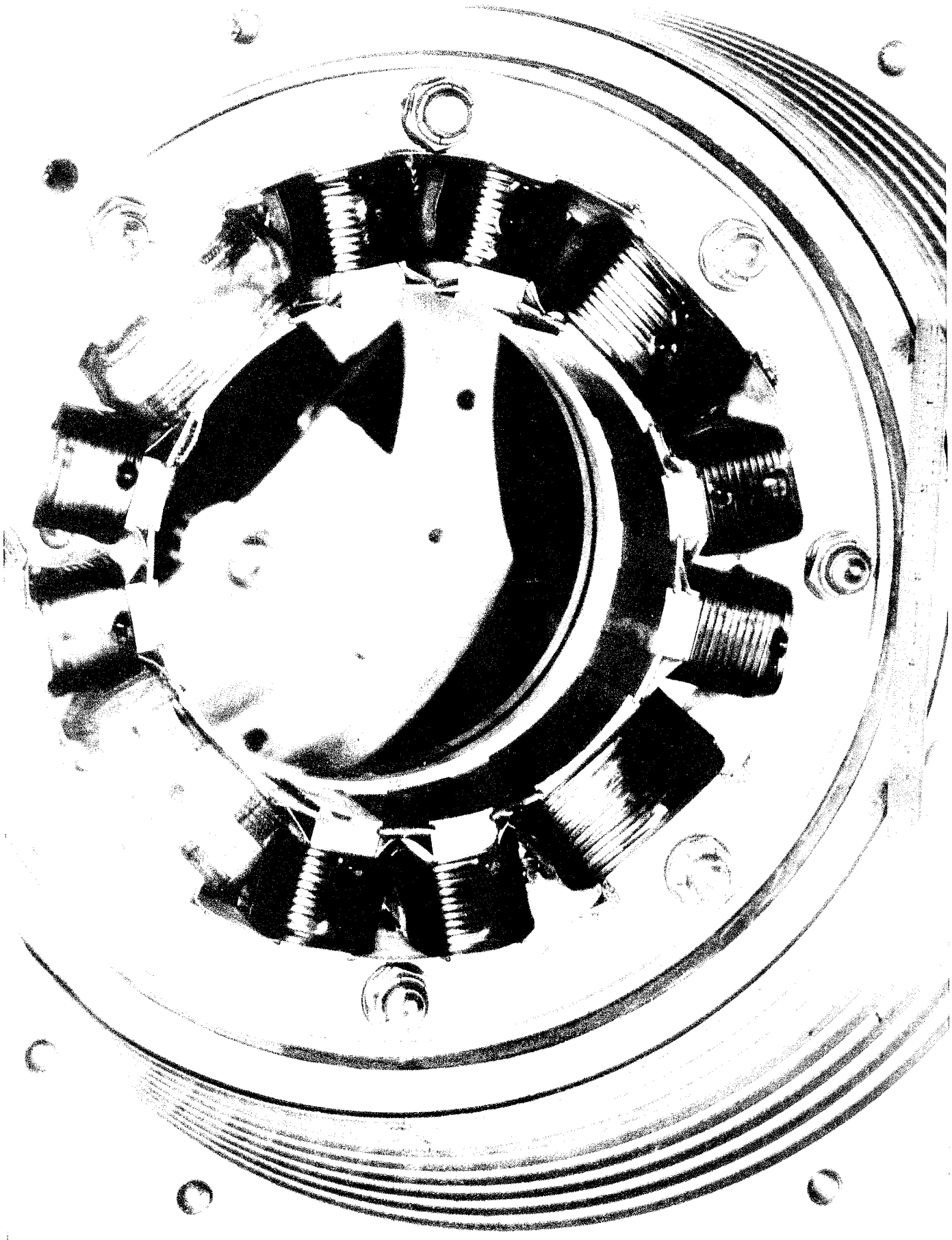
By assisting Crystal Specialties International (CSI) in the development of an improved gallium arsenide (GaAs) material, the United States Government will have this critical material available for military and civilian microwave and digital circuits. Wright Laboratory's innovative semiconducting testing methods play a key role in the development of this material. The map shown left, presenting the results of infrared absorption measurements made by the Solid State Electronics Directorate at one-thousand points on a wafer, is representative of the test information that will be used by CSI to make modifications to their process in order to improve uniformity.

Accomplishment

The Solid State Electronics Directorate has successfully executed a CRDA with CSI of Colorado Springs CO, for the development of a better semi-insulating gallium arsenide wafer. CSI will grow GaAs ingots and send wafers to the Directorate for testing.

Background

Gallium arsenide devices are used in high-frequency analog and digital circuits. Applications include radar, cellular telephones, microwave communications, global positioning systems and supercomputers. All of these applications require the use of a semi-insulating (very high resistivity) GaAs wafer, usually 76 nanometers (nm) in diameter and 0.5 nm thick, as a building block for the GaAs devices and circuits. The quality of this wafer, and especially the uniformity, are very important. The semi-insulating nature is controlled by a defect called EL2, so that good EL2 uniformity across the wafer is required. CSI has for many years been a leader in the development of innovative semiconductor materials, and the Solid State Electronics Directorate has developed an international reputation for the development of innovative semiconductor testing methods. Any intellectual property rights owned by either party, the government or CSI, will remain in the possession of the owning party and will not be shared except with the consent of both parties.



Magnetic Bearing Demonstrated In Advanced Turbine Engine Gas Generator

Payoff

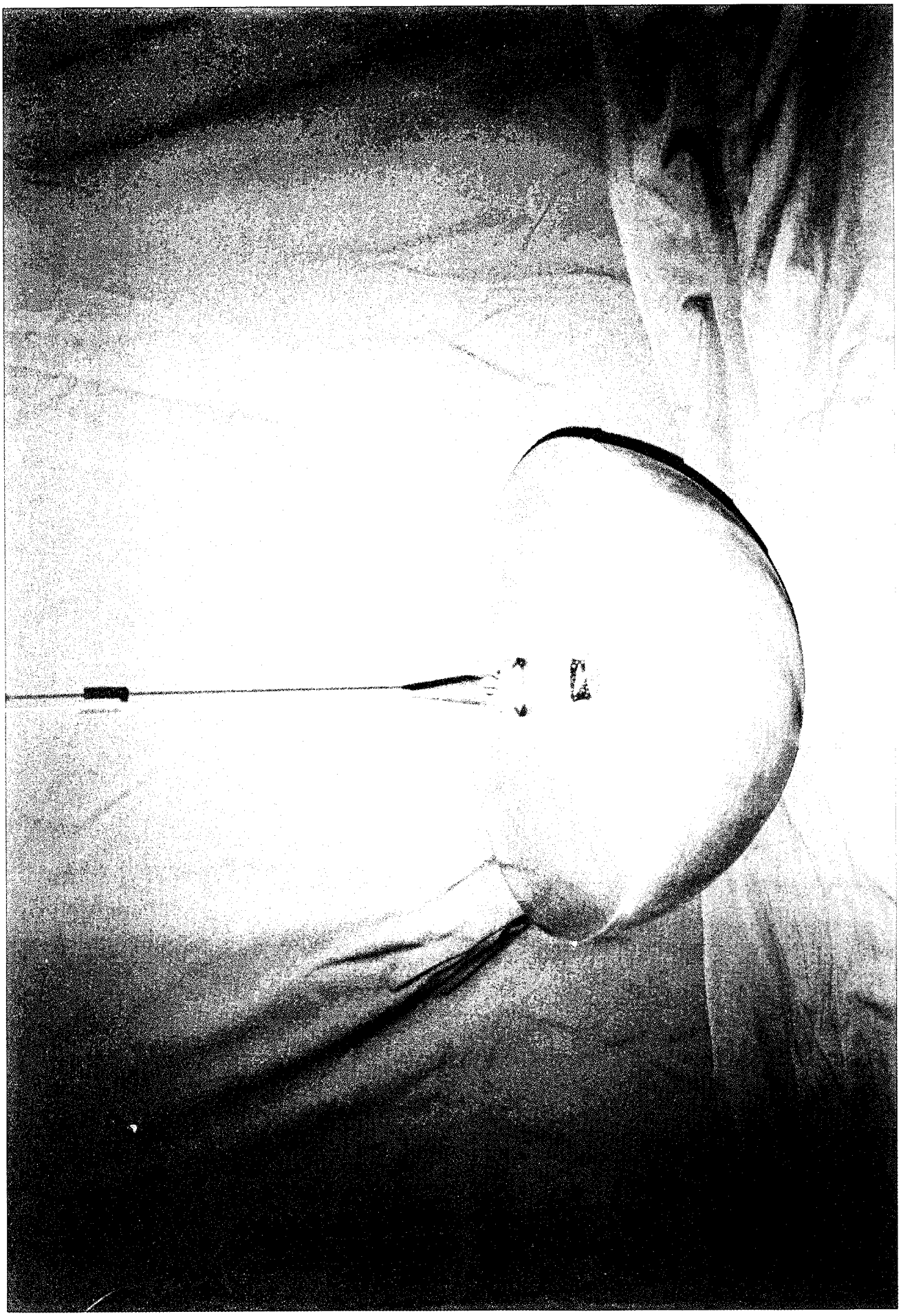
A magnetic bearing does not require conventional liquid lubrication. This allows elimination of the engine lubrication system including pumps, reservoir and plumbing. In addition to significant weight savings (10-15% reduction in engine weight if the bearing is combined with the internal starter generator), magnetic bearings will also result in reduced maintenance and lower parts count.

Accomplishment

For the first time in jet engine history, the rotor shaft connecting the compressor to the turbine of an advanced demonstrator core engine was magnetically levitated in lieu of employing conventional ball and roller bearings. This magnetic bearing, developed under a program sponsered by Wright Laboratory's Aero Propulsion and Power Directorate and the Navy, as a part of the joint DOD, ARPA, NASA and industry Integrated High Performance Turbine Engine Technology (IHPTET) initiative, performed flawlessly during a 25 hour test in an advanced demonstrator core engine.

Background

The demonstration of this innovative concept was conducted at Pratt and Whitney, East Hartford CT, in an Advanced Turbine Engine Gas Generator (ATEGG) and provided critical data necessary for the application of the technology in achievement of the final Phase II goals of the IHPTET initiative. Follow-on tests of the concept will be performed in an advanced dual spool test rig which simulates the operation of an actual gas turbine engine. Further improvements to the magnetic bearing will include the development of higher temperature magnetic materials, lighter weight power packages, and greater thermal capability.



Crash Site Locator Beacon

Payoff

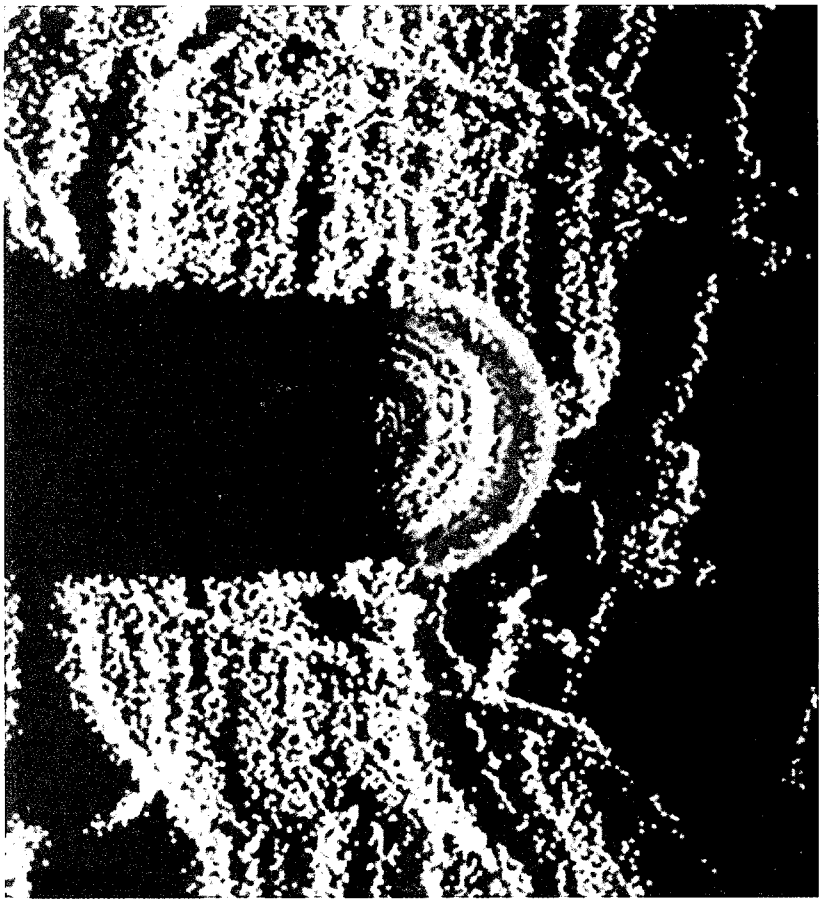
This crash site locator beacon was made in-house from commercially available components at approximately one-tenth the cost of a similarly contracted effort. This device enables air and ground recovery teams to quickly relocate a crash site to effect recovery of equipment and personnel.

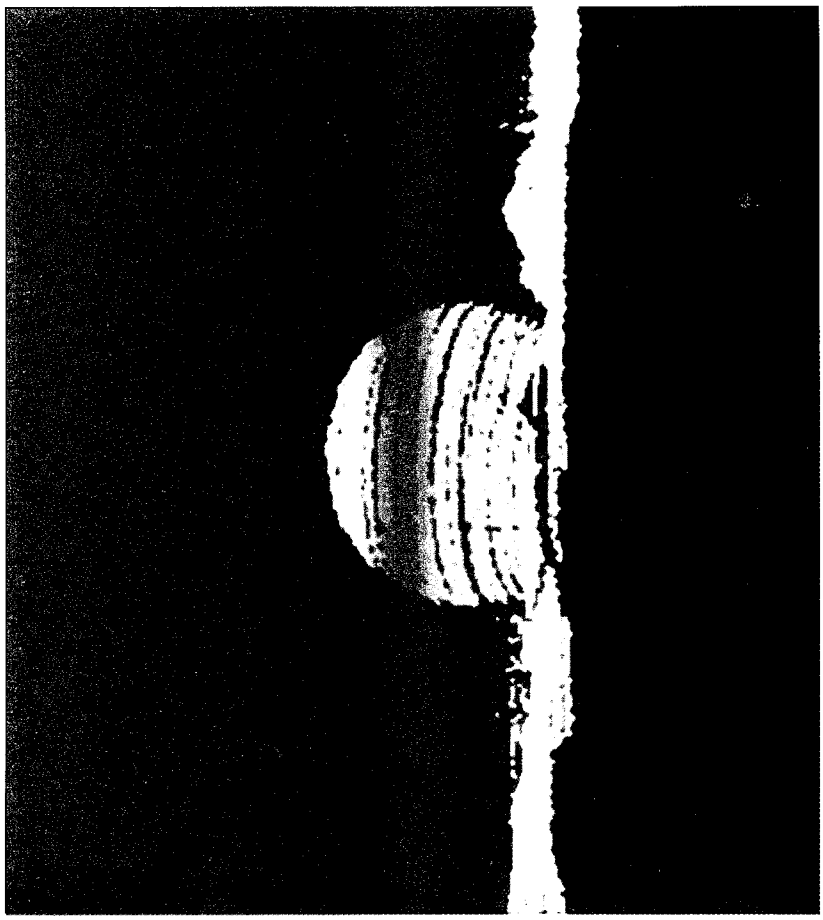
Accomplishment

In response to a request from the Alaska Air National Guard, Avionics Directorate engineers designed and built a prototype locator beacon that enables recovery personnel to relocate a crash site. The unit is designed to be air dropped via parachute from a search aircraft, to right itself upon landing, and to emit a radio frequency beacon and high intensity strobe light upon command.

Background

Personnel from the Alaska Air National Guard identified a requirement to the Avionics Directorate for a way to mark aircraft crash sites from the air so that recovery personnel could relocate the site later. The Air Guard search aircraft can define the navigational coordinates of a crash site based upon its onboard navigation systems, but their recovery vehicles are not normally equipped with navigation systems that enable quick relocation of the site. In response, the Directorate designed and built, within months, a prototype locator beacon that can be activated with a very high frequency (VHF) radio transmission enabling air and ground recovery teams to home in on its location using a VHF or ultra high frequency (UHF) automatic direction finding (ADF) unit and visual sightings of the strobe light. Two prototype units were made available to the 210th Air Rescue Squadron of the Alaska National Guard at Anchorage, Alaska in August 1993 and are presently undergoing operational evaluation.





Laser Radar (LADAR) Technology Demonstrates "Brilliant" Guidance

Payoff

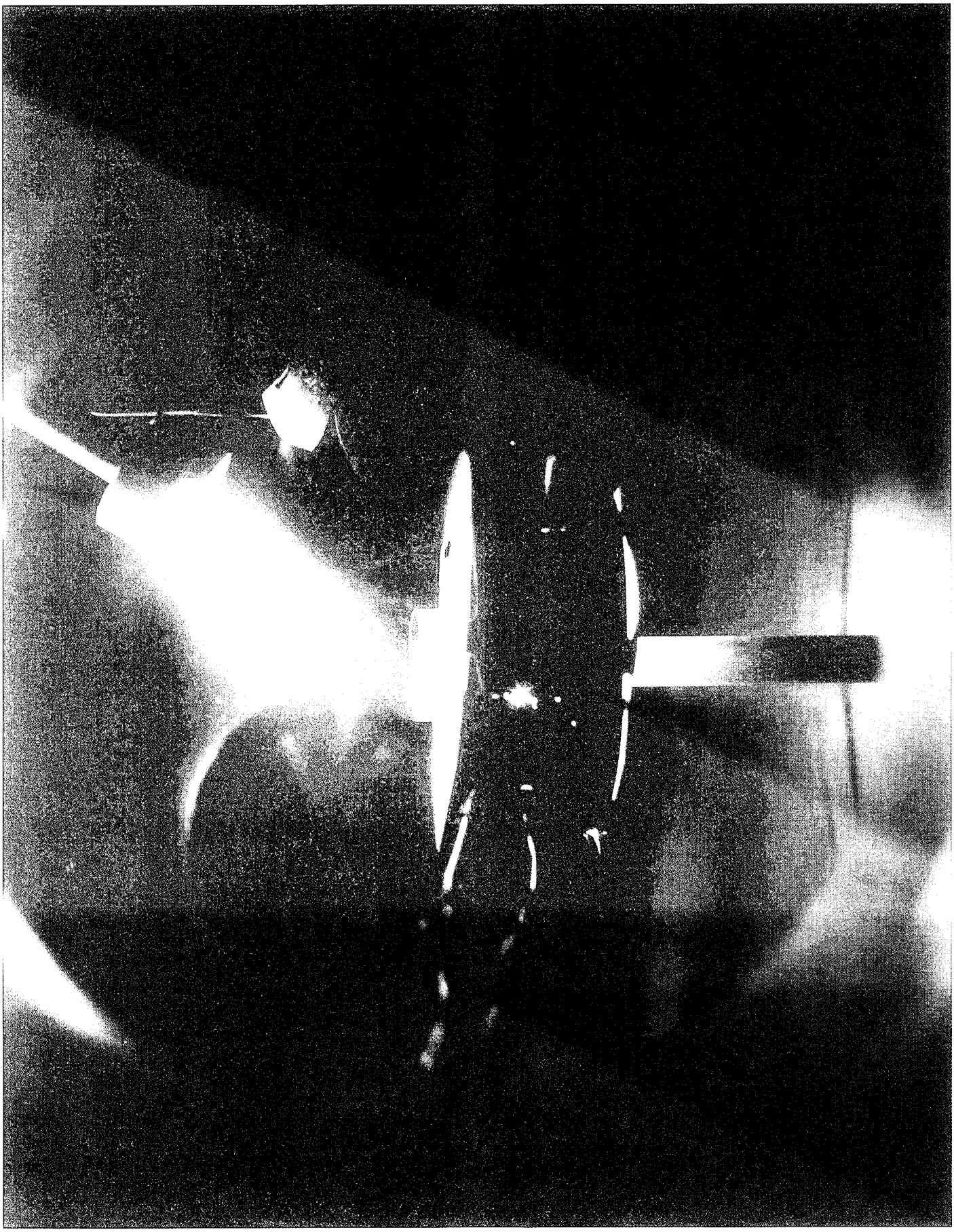
The precision guidance offered by a LADAR sensor, combined with a target recognition algorithm, provided autonomous operation for a variety of weapons. The capabilities of this system will result in reduced mission planning time and reduced pilot workload. In addition, the increase in stand-off capability, resulting from this technology, will prevent exposure of aircraft to hostile air defenses. Shown left are two separate images of a radar site radome that were generated by the LADAR sensor.

Accomplishment

The Armament Directorate, working with Hughes Missile Systems Company of San Diego CA, is one step closer to developing a guidance system for an autonomous weapon that can track and identify a variety of fixed and relocatable military targets. The Directorate's Precision Strike Office successfully conducted an extensive series of captive flight tests in which an Advanced Technology LADAR Seeker (ATLAS) identified bridges, industrial facilities, military installations, armored vehicles and other militarily important targets.

Background

Current technologies require extensive human interaction in guiding bombs to their targets. In February 1990, the ATLAS program was initiated to demonstrate a fully autonomous precision guidance capability using LADAR seeker technology as a way to eliminate the need for human interaction. A LADAR sensor uses a laser beam to provide range information to a series of points on an object. The location of each point can be determined to within one foot in all three dimensions. The points are combined into a common geometric coordinate system to create a three-dimensional image of the object and its surroundings. The image is coupled with "brilliant" algorithm concepts to identify a particular target and locate a predetermined aimpoint. This capability, against a variety of targets, allows greater flexibility in the munition's use, as well as retargeting after aircraft takeoff. The "brilliant" algorithms (hosted by the on-board seeker/processor) reduce mission planning time and pilot workload. Since the LADAR seeker is released at stand-off range, it prevents exposure of the aircraft to hostile air defenses. The autonomous operation is applicable to a variety of weapons, from glide bombs to long-range cruise missiles. High-powered, compact lasers and range filtering techniques have improved the imaging capability in some adverse weather and battlefield smoke conditions, problems which have normally hampered laser seekers.



Self-Directed Control Of Pulsed Laser Deposition (PLD) Improves Quality Of Coatings

Payoff

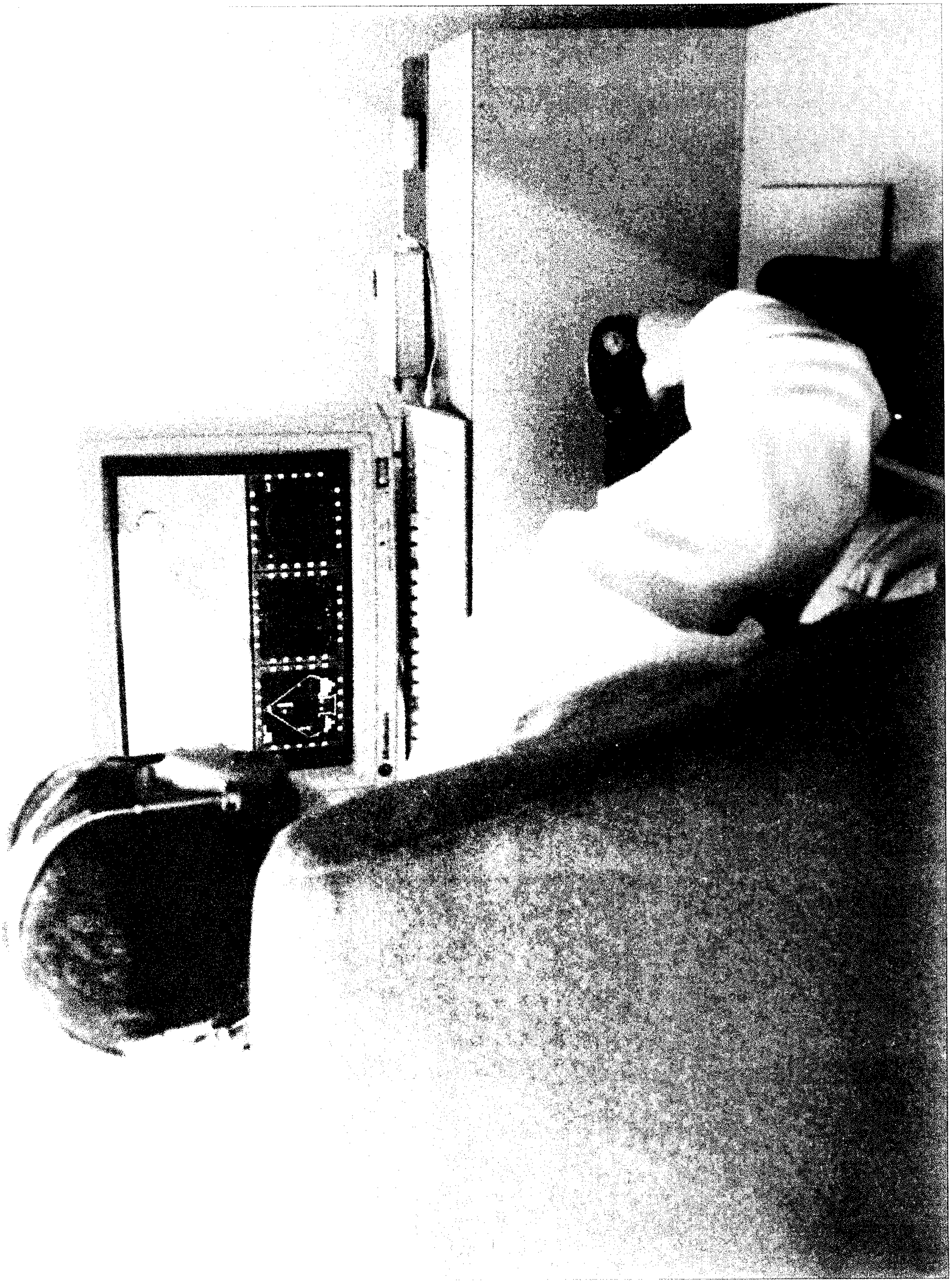
The self-directed control system for PLD (demonstrated left) will reduce costs and lower the frequency of failures for PLD applications: such as high-temperature solid lubricants in future turbine engines and computer disk drives with vacuum-sealed bearings. Its use enables PLD to be a competitive coating process, while reducing operator exposure to scattered ultraviolet laser light.

Accomplishment

Materials Directorate and University of Cincinnati researchers collaborated to develop an intelligent system that automatically controls a laser process for applying high quality thin-film coatings. Their self-directed control of the PLD process performs the deposition operation ten times faster than the traditional manual process, while improving the quality and consistency of the coatings.

Background

PLD involves depositing a relatively thin layer or coating of a material onto the surface of an object. Laser pulses, fired in rapid succession, impinge on the material surface, causing a plume of material to deposit on the object. PLD is particularly successful for low temperature depositions. Room temperature depositions preserve precision machining tolerances needed for machine tool coatings. The manual PLD operation does not provide consistency of growth rate or quality, and requires operator intervention. The operator must preselect laser pulse rate and energy settings based on experience, observe deposition results during the process, and attempt to manually adjust the laser parameters for thickness and quality. The new self-directed control system used artificial intelligence techniques to automatically adjust laser parameters in real-time, without operator interaction. The control system adjusts the laser parameters based on information provided by two sensors. One sensor provides an indication of the deposition amount and rate of the film material, while another obtains spectroscopic data. Using knowledge from past experiments to determine likely process behavior, the intelligent system accomplishes self-directed control of the PLD process. The self-directed control system increases the deposition rate by a factor of ten.



Expanded Field Of View (EFOV) Display

Payoff

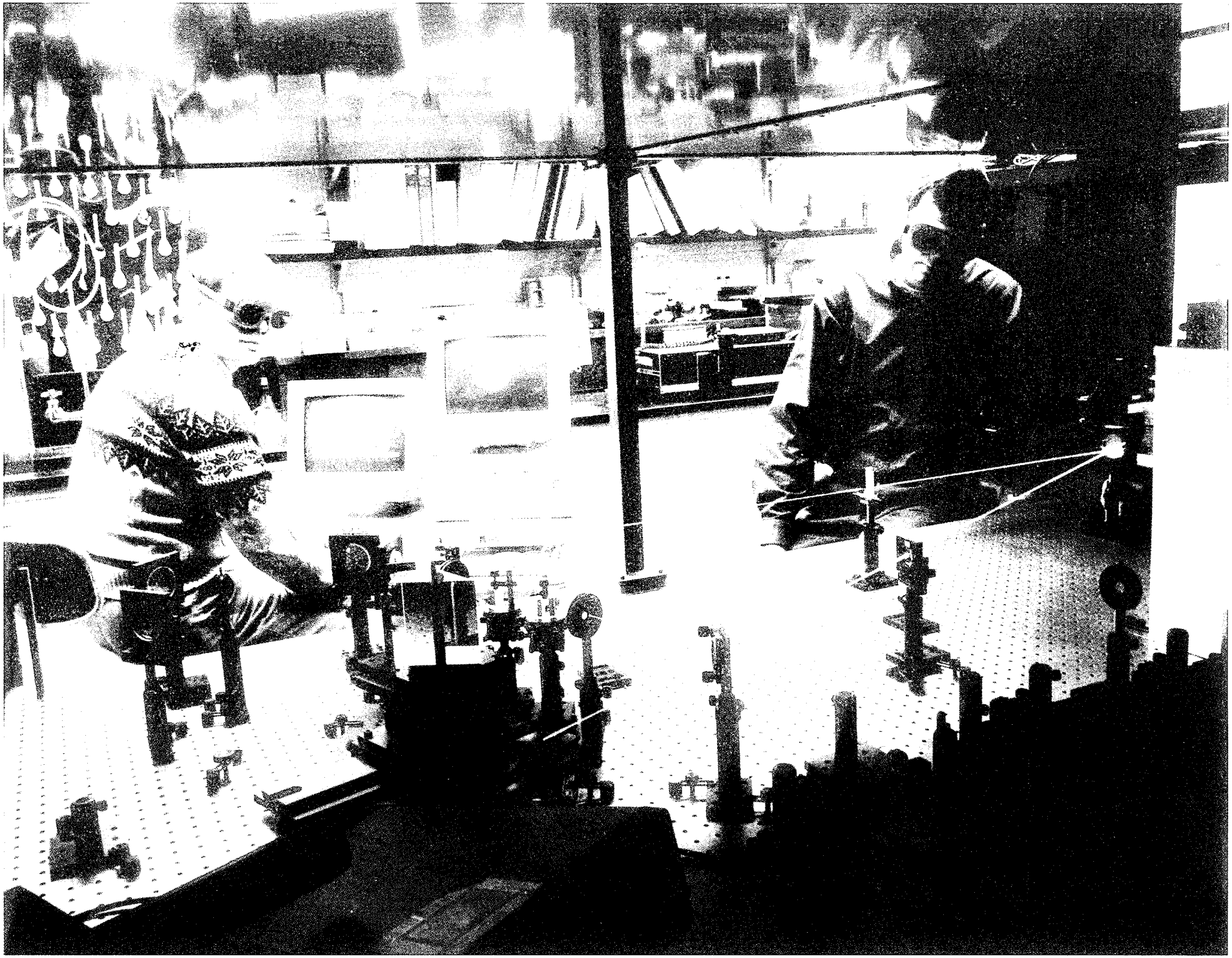
The EFOV display capability will enable the Air Force to simulate present and future aircraft, support systems and weapons in an air combat environment with several friendly, threat and neutral piloted stations. The Training System Program Office will procure up to 97 unit training devices, which use the EFOV technology, for use by F-15 and F-16 reserve and guard units.

Accomplishment

A new display technique, developed under a Small Business Innovation Research program sponsored by the Flight Dynamics Directorate, provides the capability to fly multiple manned combat simulations at a fraction of the high fidelity manned dome simulator cost. Air Force pilots, using this display, were about 90 percent as effective as a 360 degree field of view dome simulator in terms of fighting, tracking and evading abilities.

Background

The Flight Dynamics Directorate's Flight Control Division conducts research and development in the area of future air-to-air and air-to-surface combat systems. Since a realistic air combat simulation has many players in the air at the same time, the Division recognized a need for low cost manned combat station (MCS) simulators. A technology called EFOV was developed for these MCSs. This display technology has been incorporated by the contractor in a commercial application called Virtual Dome Simulation (VDS). The MCS utilizes the EFOV technique displayed on a 19" monitor driven by a dedicated real-time graphics system and integrated into the mission simulation system. Dynamic hands-on throttle and stick provide interactive, man-in-the-loop combat simulations. EFOV display information provided to the pilot includes: aspect angle from ownship to target, target's relative nose position to ownship, target's planform view from ownship and range to target.



Super Sensitive Measurement Technique Improves Optical Properties Characterization

Payoff

The increased sensitivity of this measurement technique, which uses a pulsed solid state laser to measure two-photon absorption, will enable scientists to more accurately determine the optical properties of materials that have significant application to laser hardening, optical computing, image processing, fiber-optic communication and physical chemistry research.

Accomplishment

Scientists in the Materials Directorate have developed, in-house, a technique for measuring the nonlinear absorption of light energy that is up to 100,000 times more sensitive than current methods. The sensitivity of this technique is so far beyond other current measurement techniques, that the optical path length of the material being tested can be as much as 20 times shorter than in conventional direct transmission methods to provide the same data.

Background

Scientists have gone to great efforts to study materials that exhibit nonlinear optical properties, including some organic and semiconductor materials. A variety of techniques have been explored for investigating the usefulness of these materials, including direct energy absorption measurements (nonlinear transmission). Researchers from the Materials Directorate's Electromagnetic Materials and Survivability Division demonstrated novel measurements on a series of materials, diphenyl polyenes, that involved the phenomenon known as two-photon absorption. Two-photon absorption refers to the simultaneous absorption of two photons of energy by the molecules of a material when irradiated with a laser beam. The measurement technique developed by these scientists uses a standard test method called degenerate four-wave mixing. It involves the irradiation of a material by a laser beam that has been split into three different beams. A fourth beam is generated by the interaction of the other three and is emitted from the material. In addition, two interference patterns or diffraction gratings are created by the interaction. A third pattern slowly forms due to thermal effects. This third grating cancels one of the others, leaving only an absorption grating at a certain point in time. Although this phenomenon has been observed for a long time, it has not been understood. Materials Directorate researchers first recognized that a highly accurate absorption measurement can be taken at this certain point of time.

New Extrusion Technique Improves Product, Lowers Production Costs

Payoff

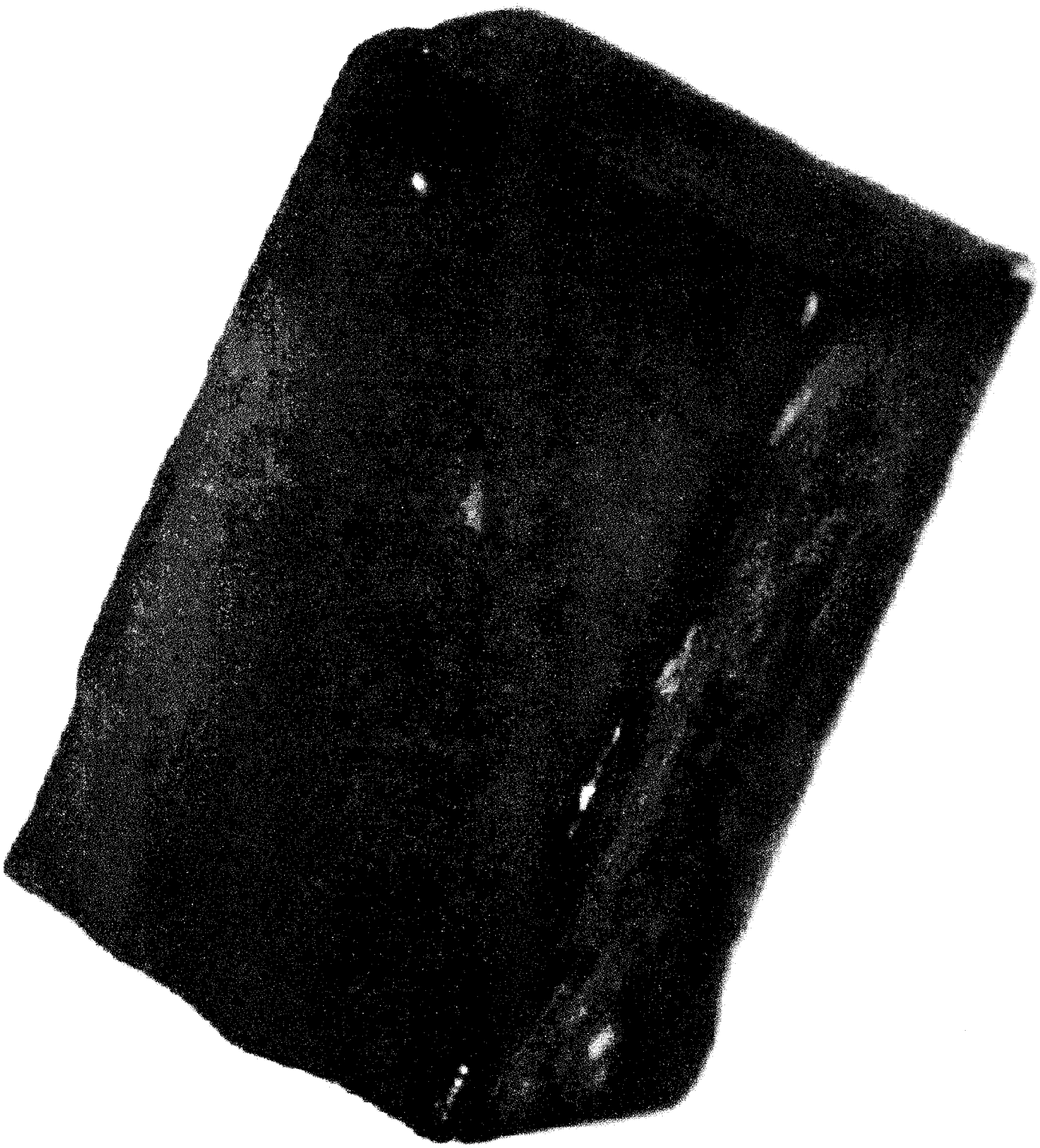
Application of the controlled-dwell extrusion technique will lower production costs, result in improved product quality, and increase usable product yield by up to 40 percent. An example of an extrusion by a conventional technique (top left sample) is shown compared to one made by the new technique (bottom left sample).

Accomplishment

Materials Directorate researchers have developed an improved method for extruding high temperature metallic and intermetallic materials. Their controlled-dwell extrusion technique is applicable for a wide range of billet or preform materials in a variety of forms. It can be used for extrusions from round-to-round or from round-to-other simple or complex cross sectional shapes.

Background

A large number of high temperature metallic and intermetallic materials are under development for applications in current and future aerospace systems. To shape semi-finished or finished products of such materials, deformation processes are often used. One such process is extrusion-forcing a heated material through a die to form a desired shape or cross-section. Conventional extrusion procedures do not work well for advanced high temperature materials. In these instances, the difficult-to-work alloy is usually encased in a protective can, preheated in a furnace, and extruded as rapidly as possible. Problems with the conventional procedure include failure of the can/billet and low product yield, often producing waste of up to 40 percent per extrusion. Until recently, it was believed that any dwell period in air following heating and prior to extrusion would be disadvantageous because of heat loss. However, engineers in the Materials Directorate's Metals and Ceramics Division have demonstrated otherwise through the use of process models and validation experiments. They developed the concept of a controlled-dwell, procedures to estimate specific processing conditions, and an approach for designing billet-can interface layers to control the magnitude of interface heat transfer. Specifically, the process for controlled-dwell extrusion is based on canning the high temperature alloy in an inexpensive can material, typically a stainless steel or conventional titanium alloy. It involves setting up a temperature difference between the can and billet prior to extrusion by controlling the dwell period outside the furnace. By this means, the flow stress of the can and billet can be made almost equal, improving the uniformity of material flow during extrusion, avoiding can and billet failure, and resulting in greatly improved product yield. The final extrusion product can be either semi-finished (e.g., forging bar stock) or finished (e.g., a structural aircraft component). The controlled-dwell technique has been validated in experiments by the Materials Directorate and by industry.



Collaborative Effort Develops Corrosion Resistant High Temperature Intermetallic Materials

Payoff

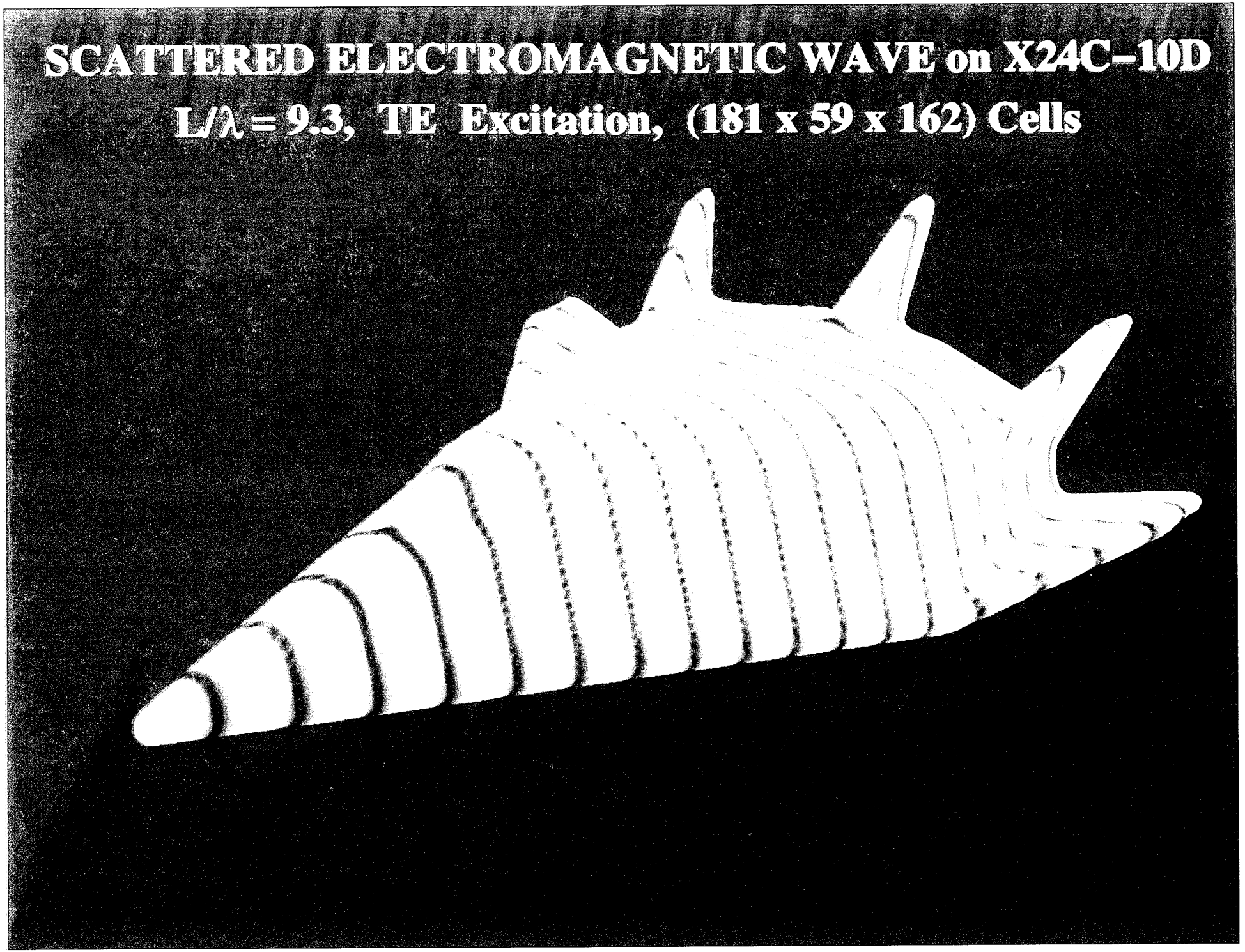
Development of advanced intermetallic heat resistant materials, such as a Niobium-Titanium-Chromium-Aluminum alloy, offers more corrosion resistant, higher melting point alternatives to conventional materials being used in high temperature propulsion applications. A sample of this alloy after static oxidation testing at 1200° C, is shown left. These materials may initially be applied to engine exhaust ducts and other sheet-type components and have a potential for use in more complicated shapes, such as engine blades and vanes.

Accomplishment

Researchers at the Materials Directorate and General Electric have teamed to develop a series of advanced intermetallic heat resistant materials with increased corrosion resistance over conventional materials. The new materials show significant decreases in recession rates due to oxidation, have a significantly higher melting point and maintain strength/creep characteristics when compared to conventional materials.

Background

Aircraft propulsion system requirements for performance and reliability continue to increase as new aircraft are developed. These new systems require materials that can withstand high temperatures for long periods and even higher temperatures at frequent, shorter intervals (during afterburner). In addition, they must not degrade over time through effects like oxidation. Components, such as exhaust ducts and vector nozzles must meet long-life requirements, while withstanding the very high temperature engine exhaust gases generated by these systems. Many of today's commercially available materials for these applications are not very corrosion resistant and can melt under high temperature conditions, causing burn through and catastrophic failure. The Materials Directorate's Metals and Ceramics Division contracted with General Electric to assist with in-house development of materials that could endure such conditions and avoid failure. These new materials involve alloying Niobium with transition metal elements. These additions create a multi-phase beta-plus intermetallic alloy. General Electric developed a series of Niobium-Titanium-Hafnium-Aluminum alloys, while the Materials Directorate went a different direction and developed a Niobium-Titanium-Chromium-Aluminum alloy. Tests have shown the Materials Directorate material reduces oxidation at 1200° C by up to 99 percent compared to commercially available B-66 and up to 93 percent compared to superalloys. Tests at the same temperature for the General Electric material show at least a 44 percent reduction in oxidation versus B-66. Additional tests for one General Electric alloy have shown that it is as strong and creep resistant as commercially available materials for the same applications. This material has also been formed and ground-tested in an F100 engine.


SCATTERED ELECTROMAGNETIC WAVE on X24C-10D
L/λ = 9.3, TE Excitation, (181 x 59 x 162) Cells

New Capability In Radar Cross Section (RCS) Simulations

Payoff

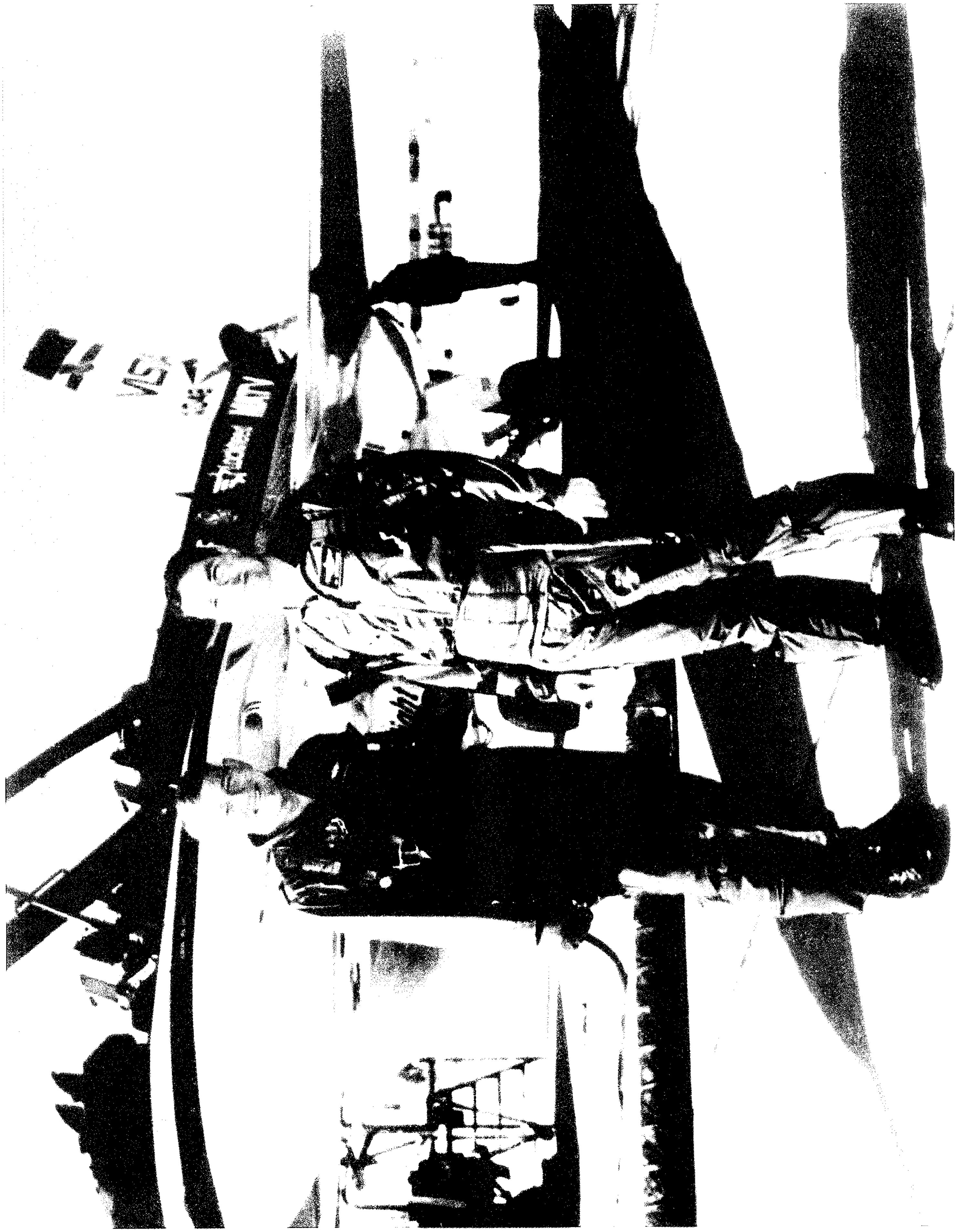
The capability to efficiently and accurately simulate the RCS of scaled aircraft models provides a computational electromagnetic technique that can be used to support DOD's critical technology thrusts in signature analysis and processing.

Accomplishment

The Aeromechanics Division of the Flight Dynamics Directorate has developed and validated a new computer simulation capability that provides a viable means of analyzing the RCS and infrared signature of aerospace vehicles. This scientific achievement is the first-ever reported radar signature prediction capability for a complete aerospace vehicle.

Background

The genesis of this technology lies in the ability to solve a large system of equations which describes the electromagnetic wave scattering phenomena around aircraft. The computer simulation can process an electromagnetic signature at a rate of 570 million floating point operations per second on a single processor of the Cray C196/16256 system, and can reach a data rate of 6.65 billion floating point operations per second on the 512-node Intel Touchstone Delta parallel system. At these data processing rates, the RCS of scaled aircraft models illuminated by a radar wave of GigaHz frequency range (optical regime) can be accurately simulated. Through a mutual support activity within Wright Laboratory, additional validation RCS data will be generated. This scientific achievement was released to the technical community for peer review at the 32nd Aerospace Science meeting of the American Institute of Aeronautics and Astronautics (AIAA), on 10 January 1994. An accompanied technical paper, AIAA 94-0231, represents the first-ever formal archive in worldwide open literature of a radar signature prediction for a complete aerospace vehicle. The RCS configuration investigated was the scaled X24C-10D reentry vehicle.



Multi-Axis Thrust Vectoring (MATV) Program Team Receives Laurels

Payoff

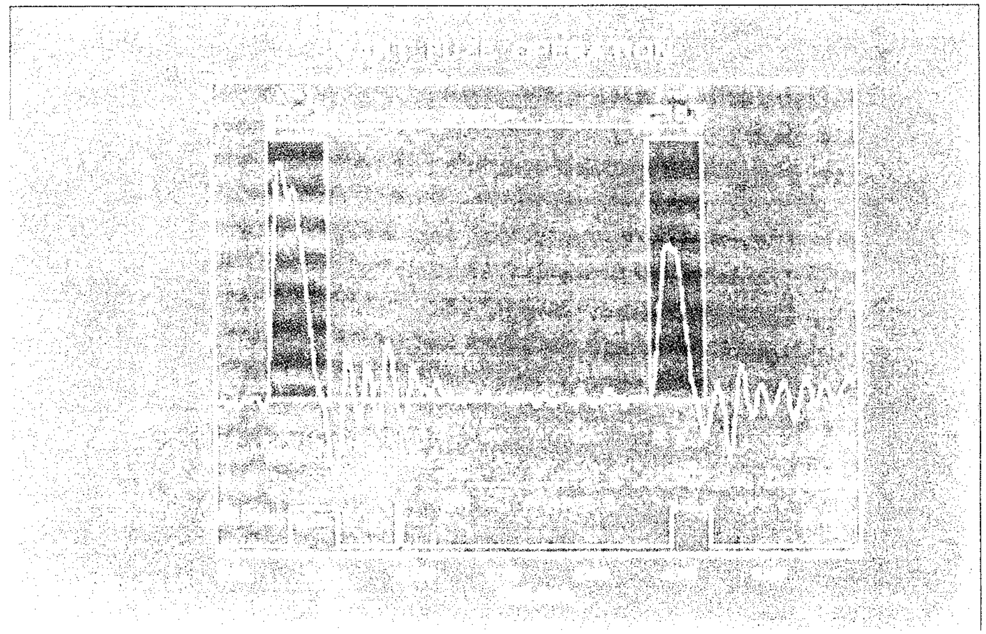
Honored in January 1994 by the Aviation Week and Space Technology Magazine for significant contributions in the global field of aerospace, the joint Flight Dynamics Directorate, Lockheed and General Electric MATV Program Team has demonstrated pitch/yaw thrust vectoring as an enabling technology. The MATV technologies offer aircraft designers and decision makers maneuverability/agility options that will enhance the operability, performance, and combat effectiveness/ survivability of derivative and future aerospace weapon systems.

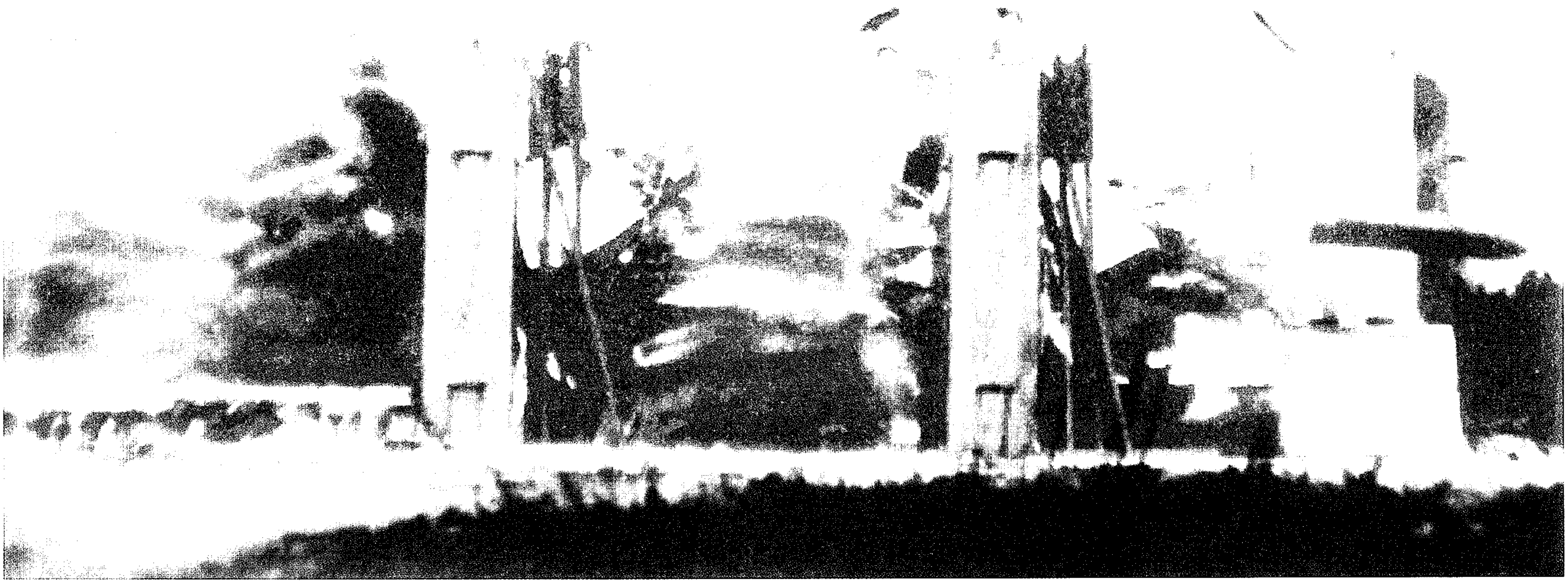
Accomplishment

The MATV Program Team was recognized by Aviation Week for contributions in the Aeronautics/Propulsion field of aerospace. This joint Air Force/contractor team, led by Lester Small from the Flight Dynamics Directorate, John Gulley from Lockheed and Roger Mishler of General Electric, received the Aerospace Laurel award for successfully demonstrating the use of integrated pitch/yaw thrust vectoring for high-angle-of-attack and low-speed maneuvering in an operational close-in-combat environment.

Background

In May 1992, the Flight Dynamics Directorate initiated the MATV Program to flight demonstrate the high angle-of-attack maneuverability benefits and evaluate the tactical utility of integrated pitch and yaw thrust vectoring on a fighter aircraft. The MATV nozzle and control hardware, and the integrated flight/propulsion control laws for the system's use on an F-16, had been developed in recent years by General Electric and Lockheed. When a planned flight test by a foreign customer fell through, the Directorate stepped in to sponsor an MATV flight test program at Edwards AFB. The Variable-Stability Inflight Simulator Test Aircraft (VISTA) F-16 was provided as the testbed, with contractor funded modifications. The inaugural MATV flight was made at Fort Worth on 2 July 1993. A total of 95 flights and 136 hours have been logged in the MATV configuration. A stabilized angle-of-attack up to 83 degrees has been achieved, while dynamic angle-of-attack during maneuvering has ranged from + to - 180 degrees. The aircraft is departure free and controllable at all attitudes and engine/inlet operability has been flawless. Post stall maneuvers have also been routinely demonstrated. Operational pilots from Nellis AFB flew the MATV against standard F-16s and demonstrated a significant close-in-combat advantage for the vectored variant. When General Ronald W. Yates, Commander, Air Force Materiel Command, took the opportunity to fly the F-16 MATV at Edwards AFB, he said, "The airplane would simply go where I pointed it, without any threat of stalls or departure from controlled flight."





Hard Target Smart Fuze For Large Penetrator Weapons

Payoff

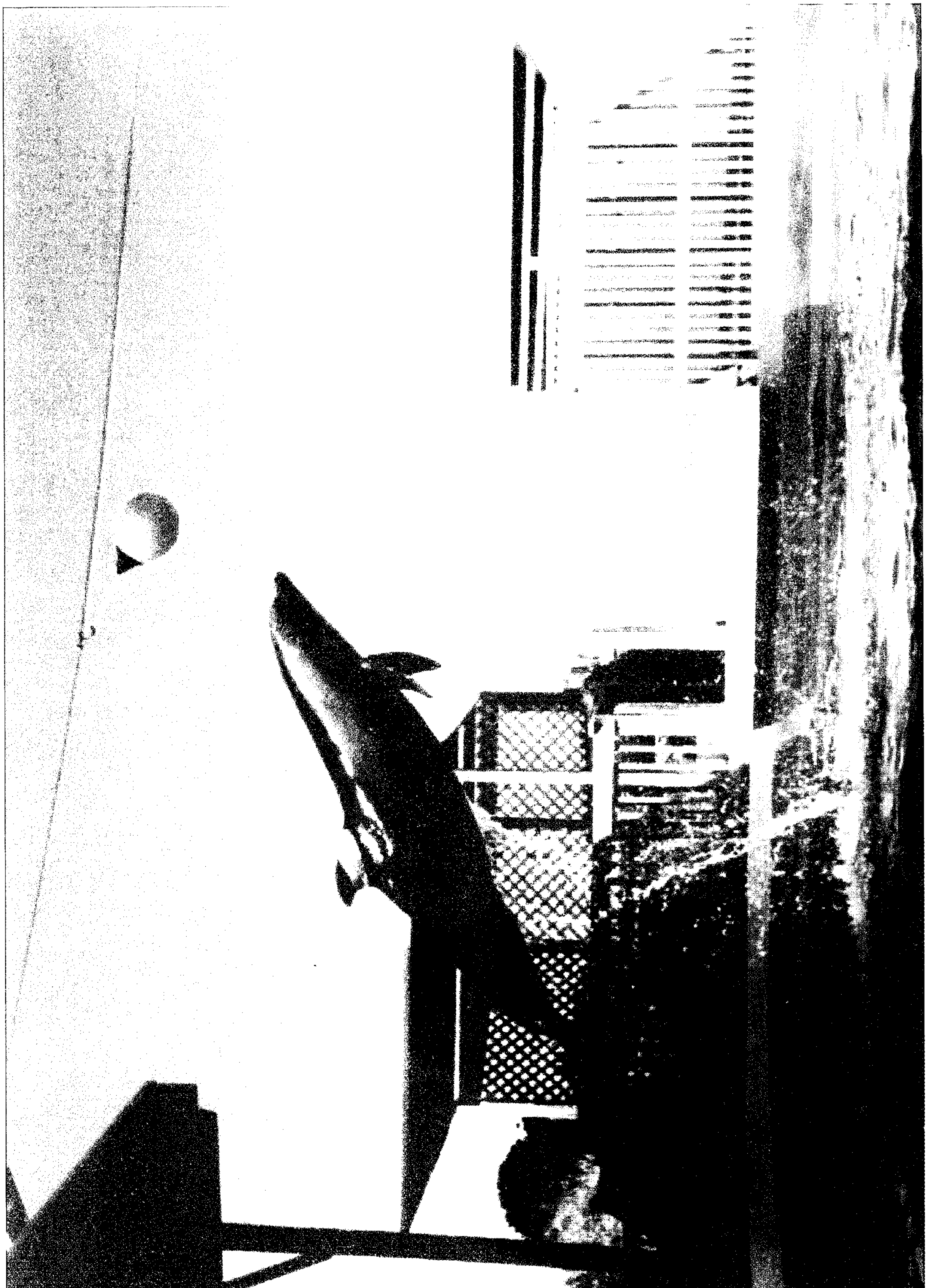
The acceleration profile shown in the insert of the photo on the left was used by the smart fuze to determine the detonation point for the warhead on the GBU-28 penetrating munition shown. The hard target smart fuze, being developed for the GBU-28 and other penetrator weapons, will dramatically improve weapon effectiveness by providing a capability to detonate the weapon at a desired point inside high-value, buried targets.

Accomplishment

The Armament Directorate has developed and fabricated a hard target smart fuze for penetrating weapons that can count concrete layers and voids, recognize when the warhead is between layers (i.e., in a buried bunker room) and detonate at the proper preprogrammed location. It has successfully undergone extensive penetration testing on both the GBU-28 (5,000 pound class weapon) and I-2000 weapons, including live tests against realistic hardened targets.

Background

Current fuzes being used in hard target weapons have a built in, preselected time delay. When the weapon hits the target, the timing mechanism is initiated and the weapon detonates after a predetermined time delay. The shortcoming with a time delay approach is that to be effective, mission planners must have near perfect knowledge of the target such as depth, layer thickness, hardness and spacing between layers. A fuze with improper timing could cause the weapon detonation to miss the crucial area of the target and limit the weapon effectiveness. Accuracy must be within milliseconds, which leaves little room for error. The new hard target smart fuze uses an entirely new concept for determining the weapon detonation point. Based on counting hard layers or voids as the weapon penetrates a target, much less target information is needed. The fuze is designed to be used with large unitary penetrator weapons. Additional flight tests with the GBU-28 and I-2000 demonstrated that the fuze performed properly under actual operational conditions. The fuze hardware tested is producible hardware, which is ready to enter an accelerated Engineering Manufacturing Development effort to provide a smart fuze capability for the GBU-28.



Dolphin Research Improved Through Use Of Subminiature Telemetry Device

Payoff

By transferring subminiature telemetry (SMT) technology originally developed for weapons testing to the private sector, the Armament Directorate is providing highly improved data collection methods to the field of marine mammal research. Research scientists will see a 100 percent increase in the amount of data collected, as well as a reduction in the time required for data retrieval. This substantial increase in data, combined with a more humane attachment of the telemetry device, will lead scientists to a better understanding of mammal habits in the wild and the impact human activities and environmental changes have on their survival.

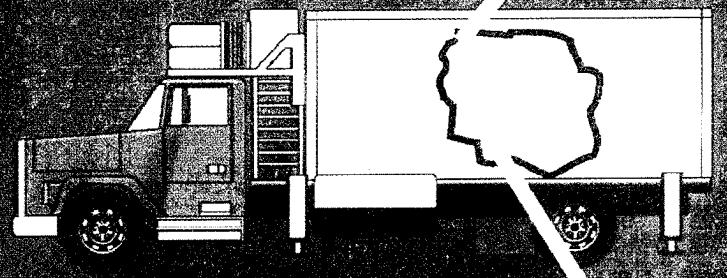
Accomplishment

Technology that was designed to improve weapon testing may provide valuable new information on marine mammals. Under a Cooperative Research and Development Agreement (CRDA) with Spectrum Sciences and Software Inc. of Fort Walton Beach FL, the Armament Directorate is transferring SMT technology to the area of dolphin research. The small size of the telemetry device allows it to be attached to a dolphin in a non-intrusive, more humane manner and its self-releasing mechanism makes it no longer necessary to recapture dolphins for data retrieval.

Background

In the past, dolphin researchers had access to only 3-4 channels of low frequency data, which was obtained in a very labor intensive manner. First dolphins were captured and bulky/heavy electronics packages were attached to their dorsal fin with bolts. Then upon release, only 15-30 minutes of data was collected, while hundreds of hours were expended relocating the same dolphin to retrieve the device for data downloading and analysis. To solve some of these problems, a research team composed of Instrumentation Technology Branch engineers, Spectrum Science and Software Inc., Ft Walton Orthopedics and Dr. Forest Townsend of the Fort Walton Beach Gulfarium are working to transfer SMT technology to the field of marine mammal research. The Air Force has developed SMT to collect performance data on small weapon systems, such as submunitions and missiles. SMT technology is a very small (one cubic inch) telemetry device made of GaAs and monolithic chip modules. Each device is capable of transmitting on upper S-Band (2310 to 2390 MHz) and monitoring up to 180 channels (128 digital and 64 analog). The Armament Directorate and the CRDA contractor are responsible for interfacing the SMT device with batteries, antennas and memory. Ft. Walton Orthopedics is designing and building a non-intrusive "saddle-pack" for housing the SMT package, which is attached to the dorsal fin by suction cups and velcro strips. After 2-3 days of wear, a spring device is activated by the corrosion of a magnesium bolt and the saddle-pack floats to the surface. Researchers are then able to use a beacon mode built into the SMT to recover and reuse the unit. Dr. Townsend is using two Gulfarium dolphins to test the design of the saddle-pack. Once the unit has been perfected, testing will begin on wild dolphins.

MOBILE INERTIAL TEST SYSTEM (MITS)



Mobile Inertial Test System

Payoff

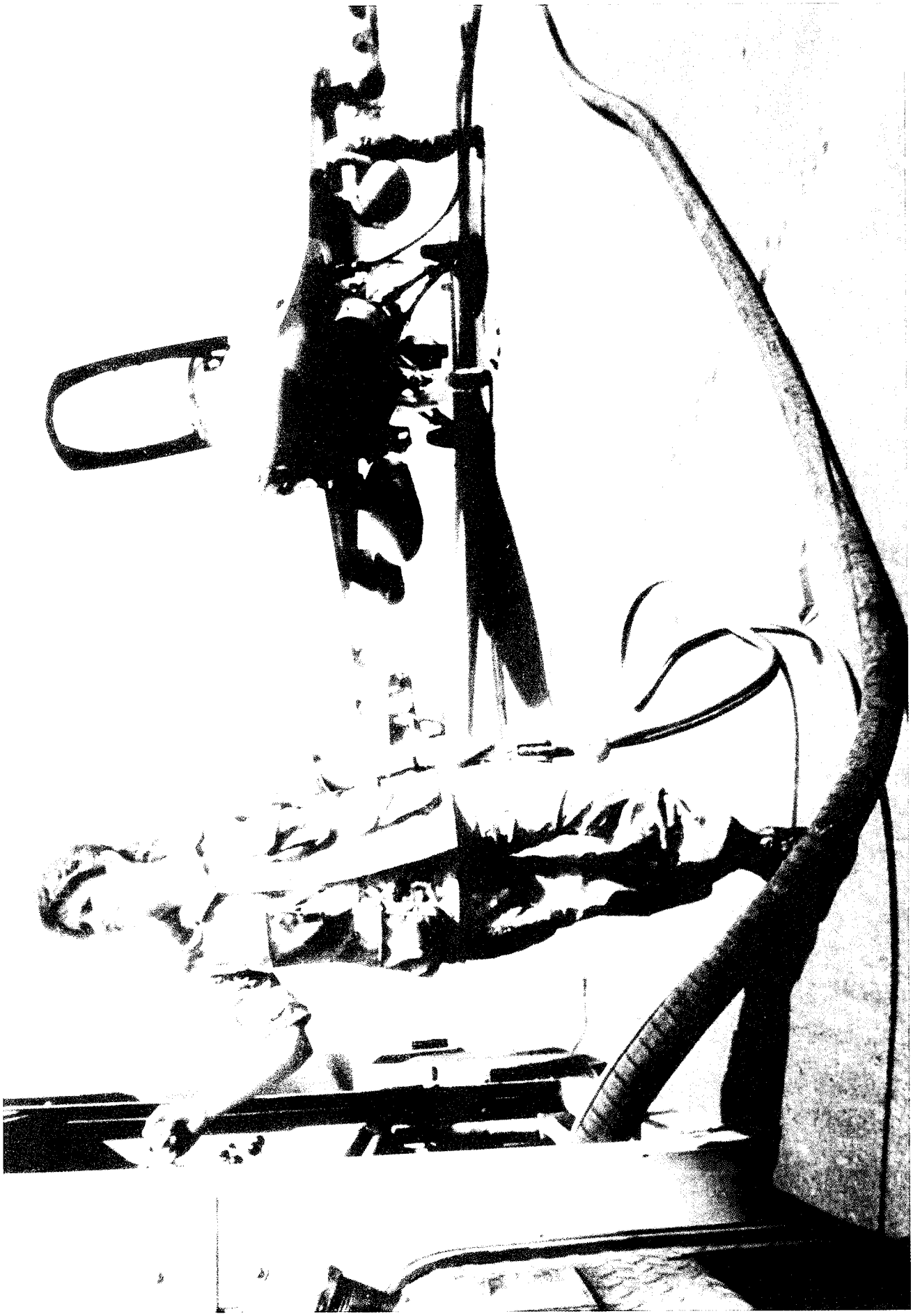
Utilization of a mobile inertial test system (MITS), to identify software problems in a guidance system prior to flight test, saves flight test costs and improves weapon system accuracy. Its application to the development of future precision weapon technology concepts will ensure the demonstration of minimum error for weapon delivery.

Accomplishment

The Armament Directorate's Navigation and Control Branch successfully developed and utilized a MITS to isolate and characterize several critical software errors in the guidance system for the Air-to-Surface Weapons SPO's Operational Concept Demonstration (OCD) program prior to flight testing. Correcting these software deficiencies prior to flight testing saved the OCD program $250,000 in flight testing costs, improved weapon system accuracy (5.5 meters was achieved) and helped ensure successful demonstration of an all-weather, precision-guided munition.

Background

Guidance packages are first tested statically (on the bench) and then flight tested. Software design flaws that go undetected during static tests are often identified during flight test, necessitating an additional flight test(s). The Navigation and Control Branch, realizing that correcting guidance system software deficiencies prior to flight testing would save flight test costs and improve weapon system accuracy, developed a van version of aircraft weapon avionics to analyze and validate the navigation performance of six OCD guidance kits. Its assistance to the SPO ensured a successful demonstration of an all-weather, precision-guided munition using an integrated global positioning system (GPS) and an inertial navigation system (INS) solution as part of its guidance package. MITS is a mobile test bed in a van. It is designed to dynamically test the navigation performance of advanced, tactical-grade inertial sensors, inertial measurement units (IMUs) and GPS receivers. Sensor navigation performance is scored against truth reference data that is formulated by integrating a master INS with a precision code (P-code) GPS receiver. The master INS is an aircraft-quality Honeywell H423 standard navigator, and for OCD, the P-code GPS receiver was the Rockwell Collins 3A. Aircraft databus communication between the multiple system was performed using a ruggedized MicroVax computer as a 1553 bus controller.



Conversion To JP-8 Fuel

Payoff

Air Force and Army conversion to JP-8 fuel greatly increases the survivability of aircraft, by reducing post crash fires and projectile induced ignitions. In addition, JP-8 greatly reduces the risk of aircraft fires and explosions, both in-flight and on the ground. Standardization with commercial jet fuel will enhance availability and simplify logistics throughout the world.

Accomplishment

JP-8 fuel was developed by the Aero Propulsion and Power Directorate and has been selected as the primary fuel at all Air Force and Army military locations throughout the world. JP-8 was used in war for the first time during Desert Storm. Both Air Force aircraft and Army aircraft, tanks and trucks used JP-8 without a known weapon system loss due to fuel fires or explosions. This success, coupled with its successful utilization at Air Force Bases in the United Kingdom since 1979, persuaded the Air Force and Army to make the conversion to JP-8, scheduled for completion in 1996.

Background

During the Vietnam conflict, the Air Force experienced extensive aircraft and crew losses due to the use of JP-4. In addition, the Air Force Engineering Safety Center indicated that the Air Force averaged the loss of one aircraft per year due to fuel fires and explosions. This resulted in Wright Laboratory (WL) being requested to develop a fuel that would make aircraft safer and less vulnerable when exposed to hostile gunfire. WL conducted extensive tests (including exposing aircraft fuel tanks to live gunfire) to determine the characteristics of a fuel that would offer improved safety and survivability over JP-4. This new fuel would need to be producible by refineries at the required quantities and at an affordable cost. The characteristics of JP-8 were selected so as to standardize with the commercial aviation fuel (Jet A-1), while retaining the specific capabilities needed to meet the specialized requirements of Air Force aircraft. Extensive flight and cold weather ground tests were conducted on a variety of aircraft using JP-8 in order to assure compatibility with a wide range of weapon system requirements. Since its initial validation at Air Force bases in the United Kingdom, JP-8 has successfully demonstrated its capability to provide the additional safety protection needed for aircraft and ground fuel handling systems. Following the success in the United Kingdom and in Desert Storm, where France and the United Kingdom used JP-8 in their aircraft with similar success, the Air Force and Army decided to convert to JP-8 at all military locations throughout the world.


THICKNESS LOSS
10
15
20

Topographic Radioscopy Technique Used To Evaluate New Nondestructive Inspection Systems

Payoff

The Materials Directorate developed a metrology technique that provided Oklahoma City Air Logistics Center (OC-ALC) technicians with an evaluation tool used to compare vendor proposed nondestructive inspection systems. This technique, called topographic radioscopy, ensured a fair competition and provided valuable feedback to the vendors for further technology development. This program assures the Air Force that nondestructive inspection capabilities will exist to address future weapon systems corrosion damage assessment requirements. An example of the colorized corrosion maps generated by topographic radioscopy is shown on the left.

Accomplishment

Engineers in the Materials Directorate developed a measuring and mapping (metrology) technique that enabled technicians at OC-ALC to evaluate the performance of different vendor proposed nondestructive inspection systems for their KC-135 Disassembly and Hidden Corrosion Detection Program. This technique, called topographic radioscopy, provided the ALC technicians with the first available means to compare concepts for corrosion detection systems that measure and map material loss on metallic structures.

Background

The operational life of aircraft can be shortened by corrosion damage if not found in its early stages. Since visual inspections cannot uncover corrosion hidden inside aircraft structures, and in most cases it is not economically feasible to disassemble major aircraft components to check for corrosion, nondestructive inspection techniques are required. OC-ALC is sponsoring a program called the KC-135 Disassembly and Hidden Corrosion Detection Program to identify off-the-shelf technologies which will help the depot perform such inspections. Nondestructive inspection tools being developed by vendors were to be evaluated in this program; however, no industry method was available to create a solution set for demonstration comparisons. Engineers in the Materials Directorate's Systems Support Division were asked to develop a tool capable of measuring and mapping the metal loss due to corrosion on aluminum aircraft skin, so that the vendor's inspection tools could be evaluated and compared. They developed a laboratory metrology technique to characterize the location and extent of exfoliation corrosion damage on sample KC-135, B-52 and E-3 aircraft fuselage and wing skins. Their topographic radioscopy converts a digitized image to a colorized topographical map of the corroded region. The image is calibrated, scaled and colorized to produce a "corrosion map" which represents the percent of material loss. This method has good sensitivity characteristics and has a higher accuracy and spatial resolution than digitized film X-ray techniques. It also requires less set-up and processing time than film radiography. Its independence from slight contour variation makes this technique ideal for applications similar to that used in the depot program.

Commercial Aircraft Hardening Program (CAHP)
Flight System Vulnerability Determination

Payoff

Current explosives detection techniques cannot locate charge sizes, which CAHP test results have demonstrated could severely damage a commercial aircraft. The analysis tools developed under this program will facilitate the development of hardening techniques for commercial aircraft against internal explosions, ensuring a safe and controlled landing when aircraft structures survive the initial blast.

Accomplishment

For the first time, analysis tools have been developed and utilized to identify the vulnerability of transport aircraft critical flight systems to internal explosions. The analytical process, developed and applied to a representative commercial aircraft, is being transferred real-time by the Flight Dynamics Directorate to aircraft manufacturers.

Background

For the past two years, the Flight Dynamics Directorate has been attempting to answer two congressionally posed questions: (1) How much explosive does it take to bring down a commercial aircraft; and (2) what, if anything, can be done to make it more survivable? As part of this effort, the Directorate's Flight Control Division is developing a generic flight systems survivability model for general use by the Federal Aviation Administration (FAA). This model, along with the Structures Division's dynamic response model and the Aeromechanics Division's aerodynamic loading model, will be integrated by the Vehicle Subsystems Division into an aircraft vulnerability analysis. To establish a baseline for the flight systems vulnerability determination methods, rules governing component layout and separation of redundant components were taken from the Flight Control Division's Advanced Vehicle Management System program and augmented with results from internal blast test series conducted in decommissioned aircraft at Davis-Monthan AFB AZ. An early success of the program was the resolution of damaging effects of exploding luggage (air blast vs fragments) to flight systems components. This was a first step in determining overall system vulnerability. During a test series investigating various bombs, the team identified damage from one specific luggage type which resembled the Pan Am 103 bombing in Lockerbie, Scotland. The luggage type and results were confirmed by the British crash investigation team during a recent data exchange meeting. As a result of this finding, the FAA asked the Air Force to characterize luggage explosions in the same manner that exploding warheads are characterized and to provide the results to the commercial analysts at McDonnell-Douglas, Lockheed and Boeing.

First United States Launch Of High Off-Boresight Missile

Payoff

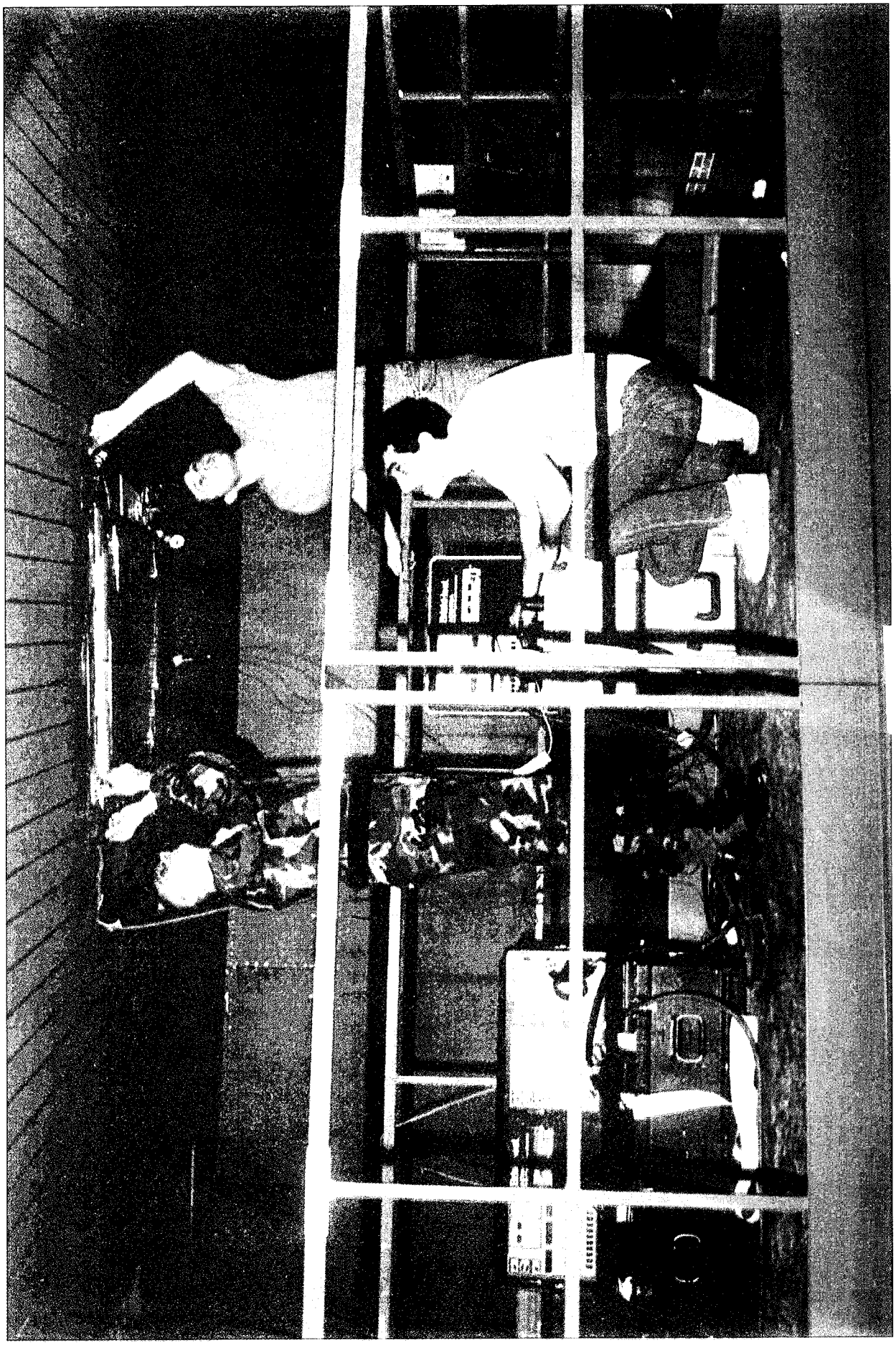
The Air Force now has a baseline performance level for close-in air combat: the ability to acquire and fire upon an opponent without having to point the nose of the aircraft at the target. This within-visual-range technology is a tactical advantage that becomes a force multiplier for current and future fighter aircraft.

Accomplishment

The first live-launch demonstration of a high off-boresight missile capability was accomplished on 11 February 1994 at Tyndall Air Force Base FL. A modified AIM-9 missile, fired from an F-16 aircraft, engaged a drone target almost 70 degrees off the aircraft's nose. This successful engagement marked the culmination of the Look and Shoot Program which was jointly sponsored by the Air Force and industry.

Background

Close-in air combat, the ability to target and fire upon an opponent without having to point the nose of the aircraft, is a tactical advantage that becomes a force multiplier. The Look and Shoot Program, first conceived by the Air Combat Command (ACC), developed an integrated missile/helmet/aircraft system to engage targets up to 90 degrees off the launch aircraft's nose. Raytheon Missile Systems provided the modified AIM-9 missile that had a newly developed seeker capable of viewing targets up to 90 degrees off the nose of the missile. Honeywell slaved the missile seeker to a helmet mounted display, causing the seeker to look at the same target as the pilot. Lockheed Ft Worth performed the system integration, while ACC provided the target drone and associated test support. Wright Laboratory funded range time, fuel, spares and other expendables, as well as providing detailed technical monitoring. This teaming arrangement was extremely effective, minimized the dollar investment of each participant and achieved the extraordinary by bringing disparate technology areas together into a "real" system in less than one year.



Improved Composite Patch Repair Process Speeds Return Of Grounded C-141 Aircraft To Operational Status

Payoff

The development and application of the improved composite patch repair process to damaged C-141 aircraft has quickly returned a number of aircraft to full operational status. The process was developed, demonstrated and transitioned to Warner Robins Air Logistics Center (WR-ALC) within 90 days. It will reduce the downtime for future aging aircraft suffering from similar damage. As sustainment of the existing Air Force aircraft fleet becomes more critical over time, this repair procedure has the potential to save many millions of dollars for the C-141, as well as other aircraft.

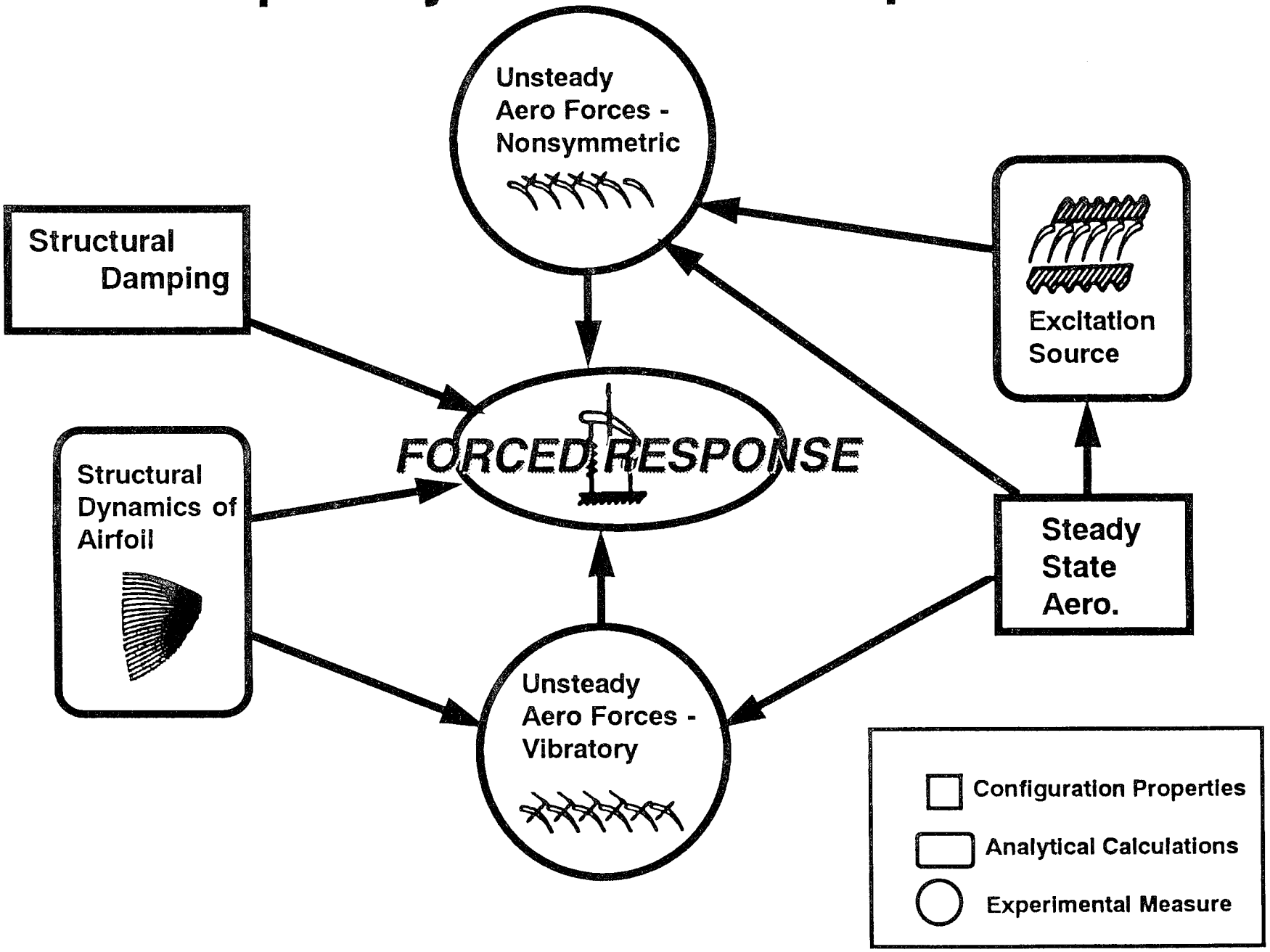
Accomplishment

Engineers from the Materials Directorate developed a composite patch repair installation process and are using it to help speed the return of damaged C-141 aircraft to operational status. Boron-epoxy composite patches have been applied to repair fatigue cracks around the aircraft's wing weep holes. The technology was transitioned to the maintenance personnel at WR-ALC, who are using the process to repair over 100 C-141s restricted from full operational status.

Background

As in many current military aircraft, the C-141 uses the space inside the aircraft's wings for fuel tanks. To allow fuel to flow smoothly between the support structures inside the wing, many one-quarter inch "weep" holes are located in the support components. Aging C-141 aircraft have been experiencing fatigue cracks around these wing weep holes. As a result of these cracks, 45 of the aircraft were restricted from flight and another 116 were limited from in-flight refueling. Replacement parts for this damage are very costly and would result in excessive downtime until parts could be obtained and installed. To speed resolution of the problem, WR-ALC asked the Materials Directorate to adapt a repair process developed by engineers in Wright Laboratory's System Support Division to repair the wing weep hole cracks. Their repair procedure involves a silane surface preparation of the aluminum structure and bonding of a boron-epoxy composite patch with film adhesive. This process requires several heat cure cycles, so numerous thermal surveys were conducted to ensure that the required temperatures could be maintained throughout the repair. Materials Directorate personnel initially demonstrated the procedure by repairing the first C-141 aircraft, which required a total of 21 different patches. Training and equipment was provided by the Materials Directorate so that Warner Robins could begin making immediate repairs. Since Warner Robins was saturated with requests for the repair work, Materials Directorate engineers also volunteered to repair four C-141 aircraft assigned to the 907th Airlift Group at Wright-Patterson Air Force Base.

Complexity of Forced Response



Government, Industry And Universities Team To Predict And Mitigate Turbine Engine Blade Vibrations

Payoff

The Guide Forced Response Consortium represents an opportunity for the turbine engine community to collaboratively develop the analytical tools needed to predict the forced response of a turbine engine and mitigate blade vibrations. The development of a prediction system will reduce the number of costly rig and engine tests required to validate each new engine component design and will lead to superior structural designs for future high performance turbine engines. Shown left is a diagram depicting the elements needed to create a forced response prediction system.

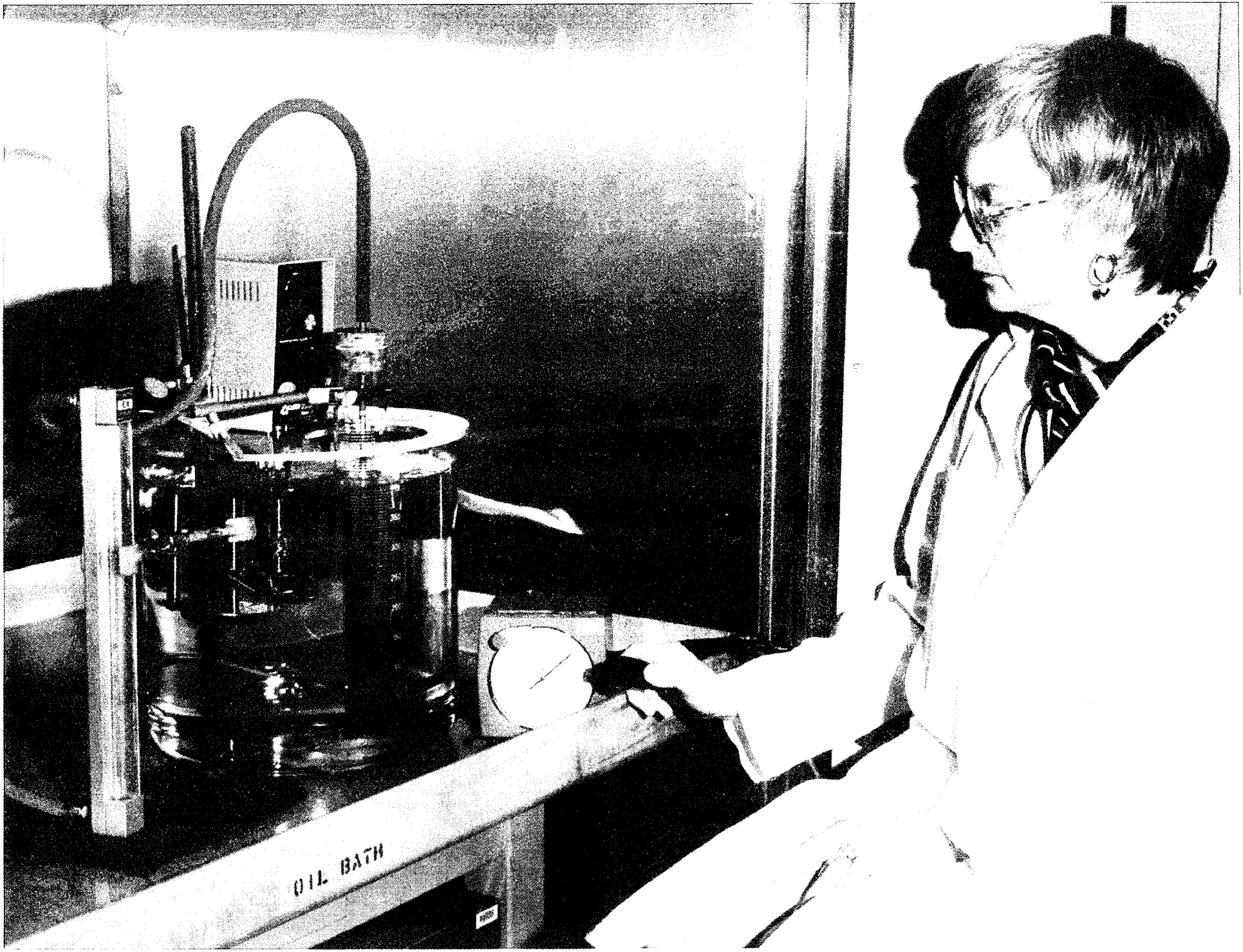
Accomplishment

The Aero Propulsion and Power Directorate was instrumental in the formation of the Guide Forced Response Consortium to coordinate research in the area of forced response analysis and prediction for turbine engines. Seven turbine engine companies, Carnegie Mellon University, Purdue University, and the United States Government signed an agreement to conduct research necessary to maintain the structural integrity of future high performance turbine engines.

Background

The joint DOD, NASA and industry initiative, Integrated High Performance Turbine Engine Technology (IHPTET), has the goal of doubling the propulsive capability of gas turbine engines shortly after the turn of the century. In order to accomplish this goal, new designs and technologies have increased and complicated the aeromechanical loading of turbine engine components. These newer highly loaded stages, swept airfoils, integrally bladed disks, and composite materials are just a few of the innovations which have changed and complicated the vibrational response of turbine engine disks and blades. To prevent duplication of effort and maximize research benefits, the turbine engine community joined together under the consortium to understand the mechanisms of forced response vibrations.

The consortium consists of seven turbine engine companies (Allied Signal, Allison Gas Turbine Division, General Electric Aircraft Engines, Pratt and Whitney, Teledyne, Textron Lycoming, and Westinghouse), the Air Force, NASA, Purdue University (Aerodynamic Research Center) and Carnegie Mellon University (Structural Research Center) with research efforts subcontracted out to top research facilities and universities. Research efforts by the consortium are jointly funded by the government (Air Force and NASA) and contributions from the participating industrial members. All efforts are directed toward the end goal of combining finite element methodology and computational fluid dynamics to predict forced response of turbine engine blades.


OIL BATH

C-130 Aircraft Engine Lubricant Foaming Problem Solved

Payoff

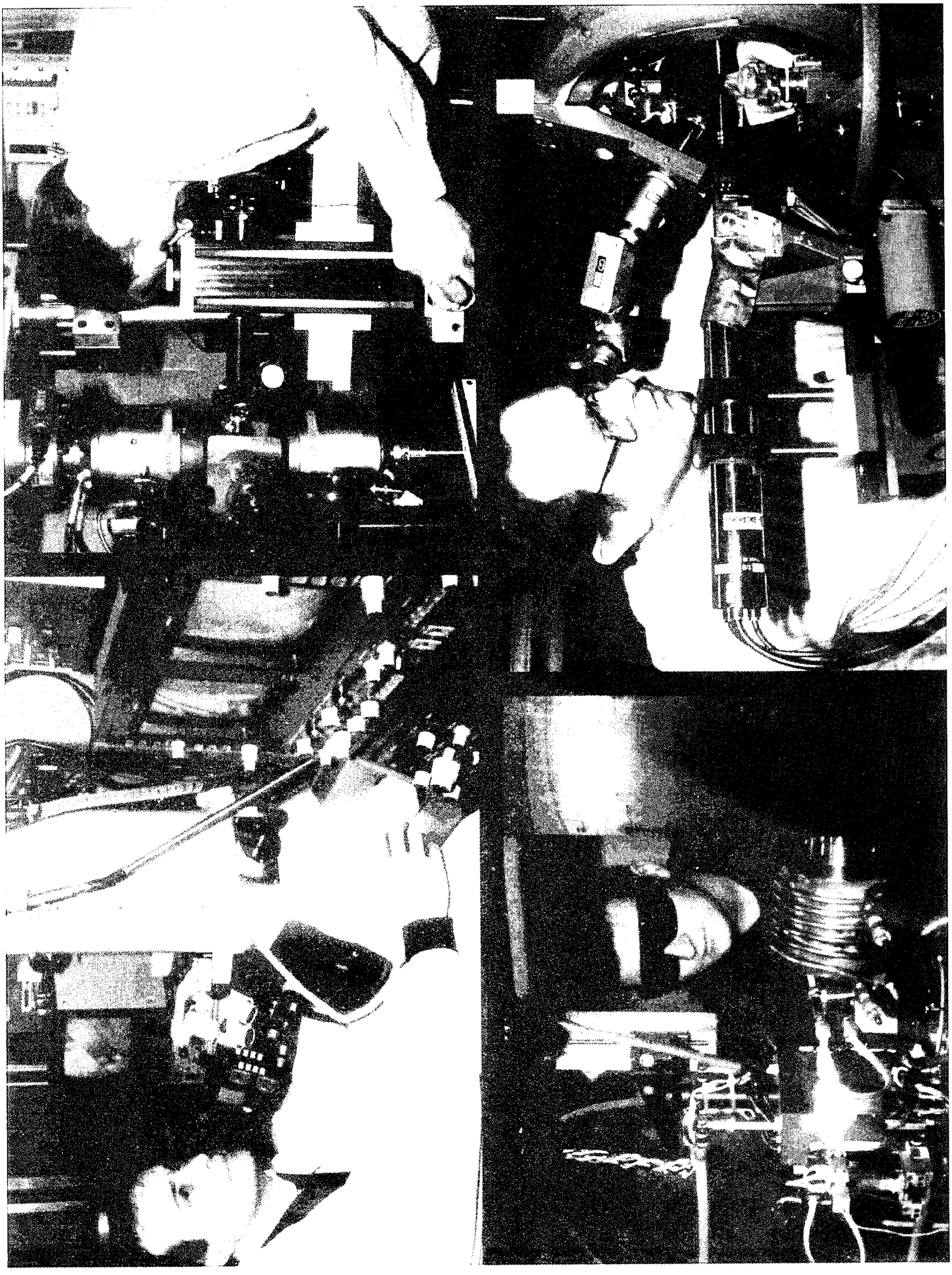
The quick solution to a T56 engine lubricant foaming problem eliminated excessive maintenance requirements that had affected the operational readiness of C-130 aircraft. This could not have been accomplished without the fundamental understanding of the cause of foaming and a close working relationship between Aero Propulsion and Power Directorate engineers, logistics center supply activities and the T56 engineering team.

Accomplishment

The Aero Propulsion and Power Directorate, working closely with San Antonio Air Logistics Center's (SA-ALC) Product Engineering Branch and T56 engineering team, solved a foaming problem in T56 engines on C-130 aircraft. This problem was adversely affecting C-130 operational readiness due to excessive maintenance requirements. Based on data generated by the Directorate, SA-ALC notified overhaul and field sites to cease use of a nonspecification spline lubricant.

Background

Incidents of lubricant foaming in T56 engines were adversely impacting Air Force operations at Savannah Air National Guard Base, Charlotte Air National Guard Base and Little Rock Air Force Base, as well as the Kodiak Air Station. These incidents resulted in additional engine maintenance requirements that included flushing of lubricant systems and numerous replacements of accessory and reduction gearboxes. To help identify and solve this problem, the Directorate's Fuels and Lubrication Division and SA-ALC engineers developed a coordinated approach to investigate the problem. Field activities were asked to provide samples of materials (especially silicones) used in mounting the gearboxes on the engines. More than 40 foam tests were performed on the samples, resulting in the identification of one silicone-based, anti-seize spline lubricant that caused gross lubricant foaming. Chromatography and infrared spectroscopy tests provided evidence that the lubricant did not meet specification base stock requirements. Analysis determined that a non-specification silicone, rather than the one required by the specification, was used as the base stock. The non-specification spline lubricant generated foam in synthetic engine lubricants 2000 times the rate of the correctly formulated product.



Air Force Office Of Scientific Research (AFOSR) Star Team Awards

Payoff

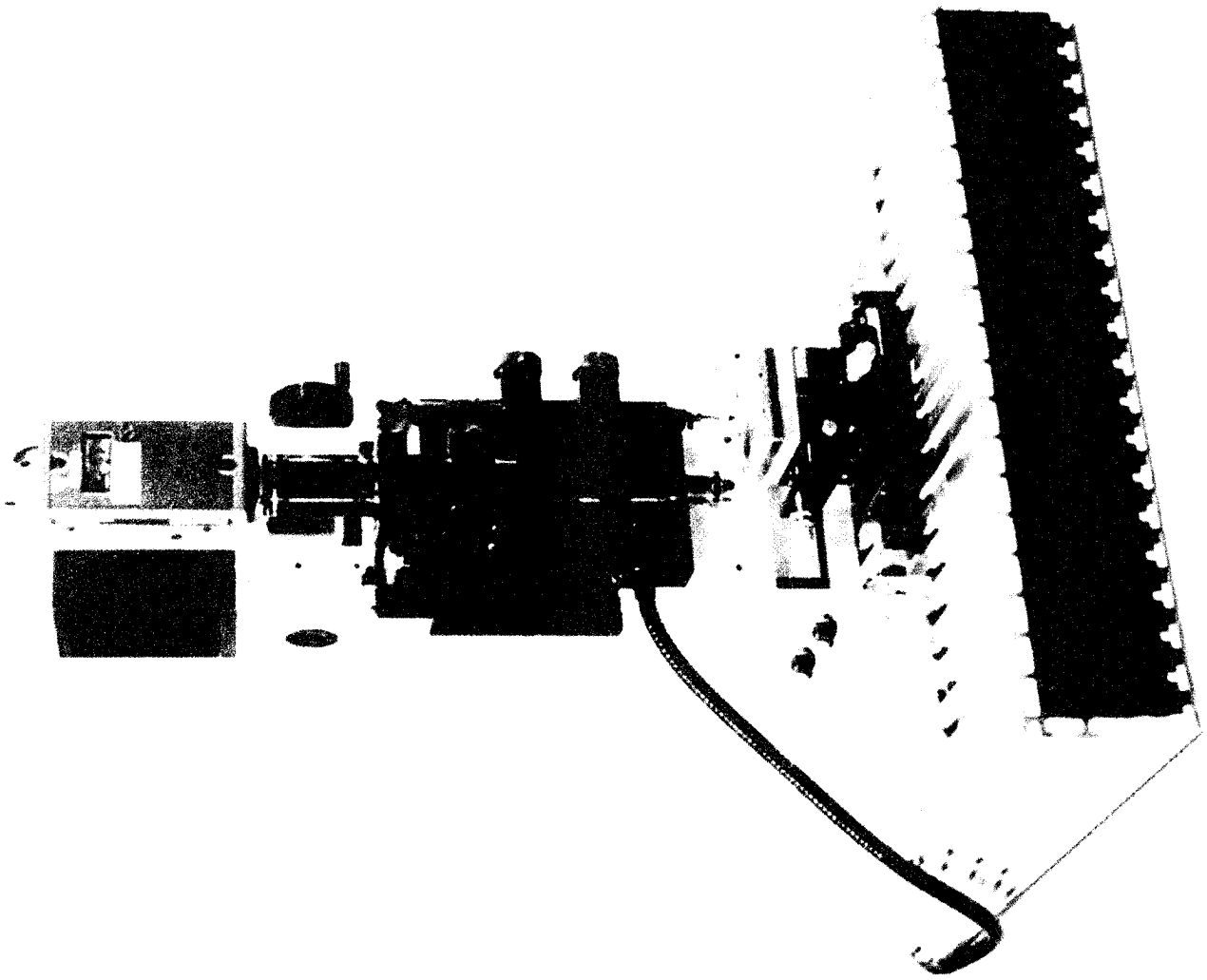
The AFOSR Star Team Award fosters excellence within the research community and highlights the critical role of basic research within the Air Force's broad technology spectrum. The 1993 Wright Laboratory Star Teams strengthen the role of basic research within the Air Force Science and Technology program by serving as role models in showcasing research achievements. The critical research performed by these teams form the foundation for the technical superiority of tomorrow's Air Force.

Accomplishment

Six teams of Wright Laboratory scientists and engineers received the 1993 Air Force Office of Scientific Research Star Team Award for excellence in basic research. The award rewards teams of researchers that have proven, through their track record, world class status in their chosen areas of research.

Background

As part of its management of the Air Force basic research program, AFOSR annually reviews the basic research of the Air Force Materiel Command Laboratories. As part of this process, AFOSR recognizes teams of researchers who have demonstrated superior scientific or engineering achievement. The research performed by the High Temperature Materials research team, led by Dr. Dennis Dimiduk of the Materials Directorate, has pioneered research in the understanding and design of intermetallics for gas turbine engine applications. Members of the Polymer Research team, led by Dr. Robert Evers of the Materials Directorate, are recognized leaders in the area of structure-properties relationships of hybrid high-temperature aromatic-hetercyclic polymers. Efforts by the Life Prediction of High Temperature Materials team, led by Dr. Ted Nicholas, have greatly expanded the fundamental understanding of the mechanical behavior of turbine-engine and aircraft structural materials under typical operating conditions. Development of the Computational Aerodynamics team's numerical simulation capability for aerospace vehicle technology will enable Flight Dynamics Directorate's Dr. Joseph Shang and his scientists to sustain leadership in computational fluid dynamics research. Significant achievements in the physics of electron and ion collisional processes in plasmas and the preparation of high quality diamond films for Air Force tribological applications have been obtained by the Collisional Plasma and Discharge Physics team, led by Dr. Peter Bletzinger of the Aero Propulsion and Power Directorate. The Computational Polymer Chemistry team, led by Dr. Douglas Dudis, was selected for its leadership on molecular modeling techniques which can be used to develop advanced polymers for Air Force structural and opto-electronic applications.



Enhancement Of Fiber Pushout Test Speeds Development Of Advanced Composites

Payoff

This interface test stand will help speed the development of ceramic and metal matrix composite materials for Air Force and commercial uses by making valuable interface property data readily available and by standardizing a test protocol. A Cooperative Research and Development Agreement (CRDA) with Process Equipment Corporation has refined and commercialized the test stand originally developed by the Materials Directorate and will facilitate the development of much needed industry test standards.

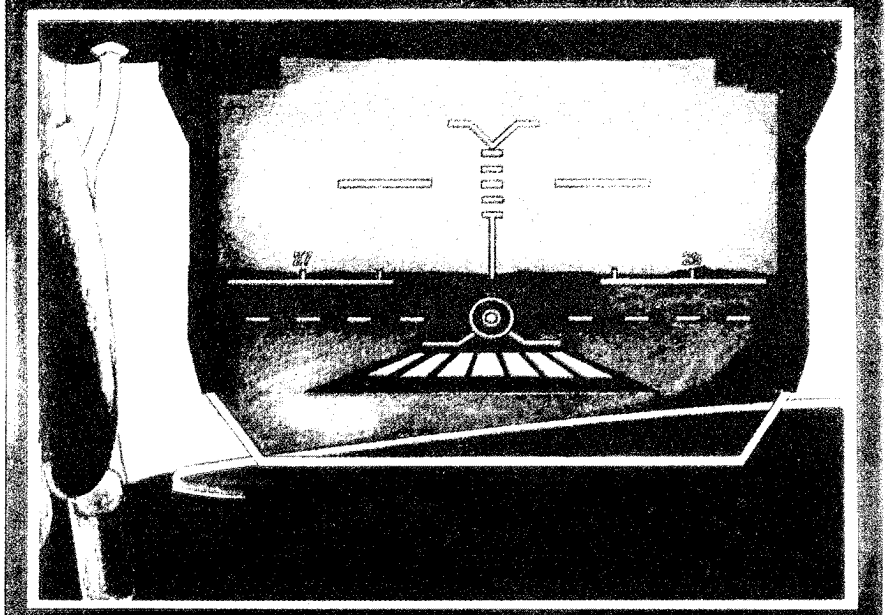
Accomplishment

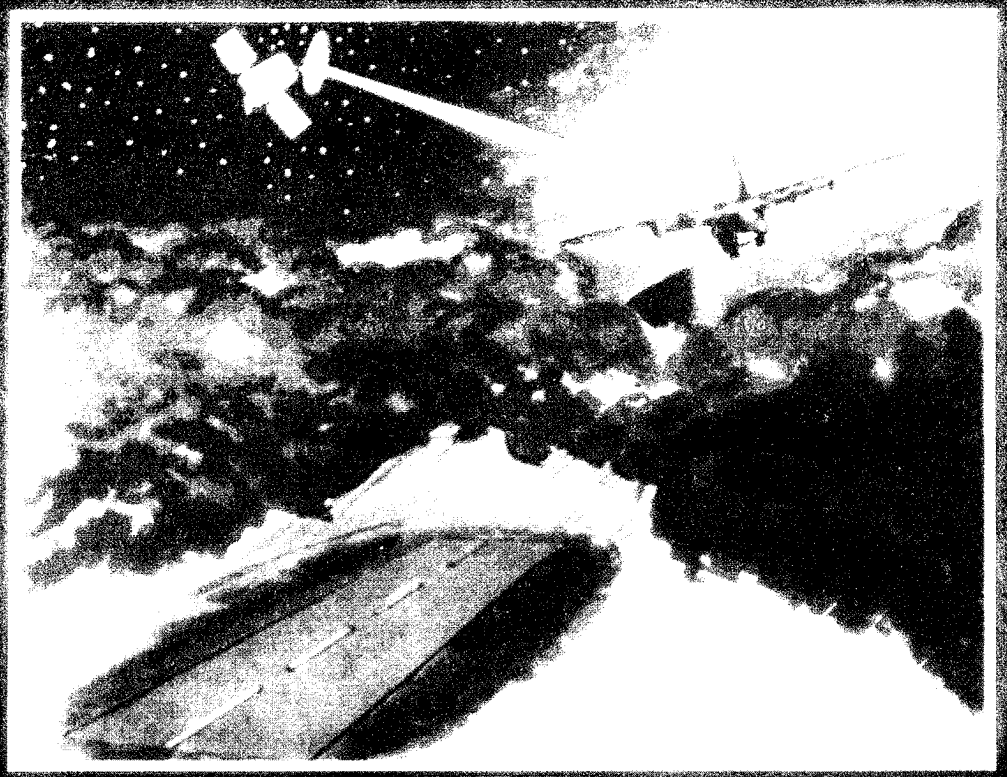
Researchers in the Materials Directorate have developed an enhanced capability for measuring important composite properties that will speed the development of ceramic and metal matrix composite materials. Their interface test stand for fiber pushout tests, which allows quantitative measurement of important interface parameters, has provided a new way to quantify interface properties and has revealed the importance of interface topography as an interface parameter.

Background

Interface properties are those properties that define the interaction between the fibers and the matrix material that make up the composite. Since these properties control the overall composite properties, it is important to understand interface behavior and be able to quantify interface properties so new and improved composites can be developed. Because of its relative simplicity, the fiber pushout test has become a preferred method of measuring these properties throughout the composites community. However, no standard test apparatus, capability and test protocol exists. Researchers in the Materials Directorate's Metals and Ceramics Division, recognizing the need for an improved ability to measure interface properties, developed an apparatus with enhanced capability and applied the test to both model systems and state-of-the-art composites. Their enhanced apparatus includes a combination of features which significantly improves its usefulness and capability. Improvements include controlled displacement, precision sample alignment, flat bottom probes (tungsten carbide and diamond), an in situ video system, a capacitance displacement probe and acoustic emission monitoring. Since no commercial version of the interface test apparatus exists, Air Force researchers approached the Wright Technology Network about finding a commercial organization to develop such a system, based on the Air Force design. After surveying fellow researchers to assure there was an interest in a standard commercial system to perform these measurements, a CRDA was signed with Process Equipment Corporation.

Autonomous Landing Guidance System





Autonomous Landing Guidance (ALG) May Save Airlines $1 Billion Annually

Payoff

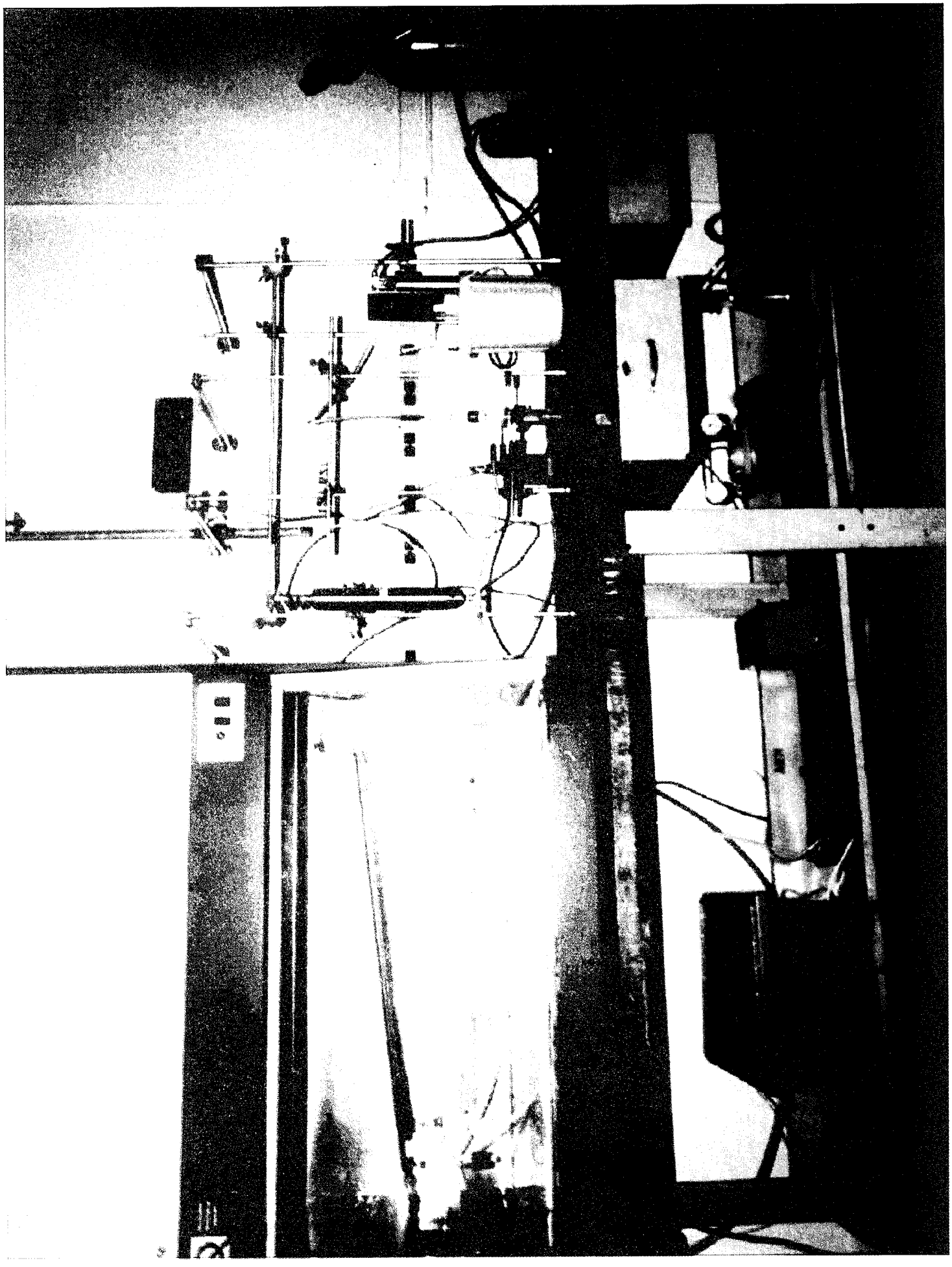
Autonomous Landing Guidance (ALG), a system that gives a pilot the capability to electronically see through dense fog and safely land an aircraft as if it were a clear day, is being transferred from exclusively military use to the commercial aviation industry. The Flight Dynamics Directorate is teaming with Lear Astronics, United Airlines and Northwest Airlines to bring this technology to the private sector. Use of the ALG system will eliminate many of the 24,000 weather related flight delays experienced each year, with a potential savings of $1 billion.

Accomplishment

ALG is one of several projects announced on 23 February 1994 by President Clinton's administration as winners in the Technology Reinvestment Program (TRP). TRP seeks to ease industries' transition from defense-related production to commercial enterprises. As a TRP selected project, ALG will receive $42 million over 24 months, with Lear Astronics Corporation as the commercial lead and the Flight Dynamics Directorate as the government lead.

Background

The ALG system will allow aircraft to land in low visibility conditions without special equipment on the ground. The concept was initially developed in 1983 by the Flight Dynamics Directorate and flight tested on the F-15 Short Takeoff and Landing/Maneuver Technology Demonstrator in 1989. The ALG system is a spin-off and an integration of existing defense-developed technologies: Global Positioning System (GPS), Millimeter Wave Imaging Radar (MMWR) and the Forward Looking Infrared (FLIR) system. The GPS is used to guide the aircraft to a sensor acquisition point. The MMWR electronically "looks" through the fog and clouds, and the FLIR augments takeoffs, landings and ground operations in low-visibility conditions. Data from these systems are presented on the Heads-Up Display (HUD), which also shows the aircraft's airspeed, altitude, attitude and heading. The FLIR image, similar to what a pilot might see through night-vision goggles, is also displayed on the HUD. According to the Federal Aviation Administration, bad weather and related airport capacity problems result in 24,000 flight delays each year accounting for high-cost losses to U.S. airlines. Other government ALG program team members include Rome Laboratory and NASA Ames Research Center.



Non-Thermal Silent Electric Discharge (NTSED) Device For Munitions Disposal

Payoff

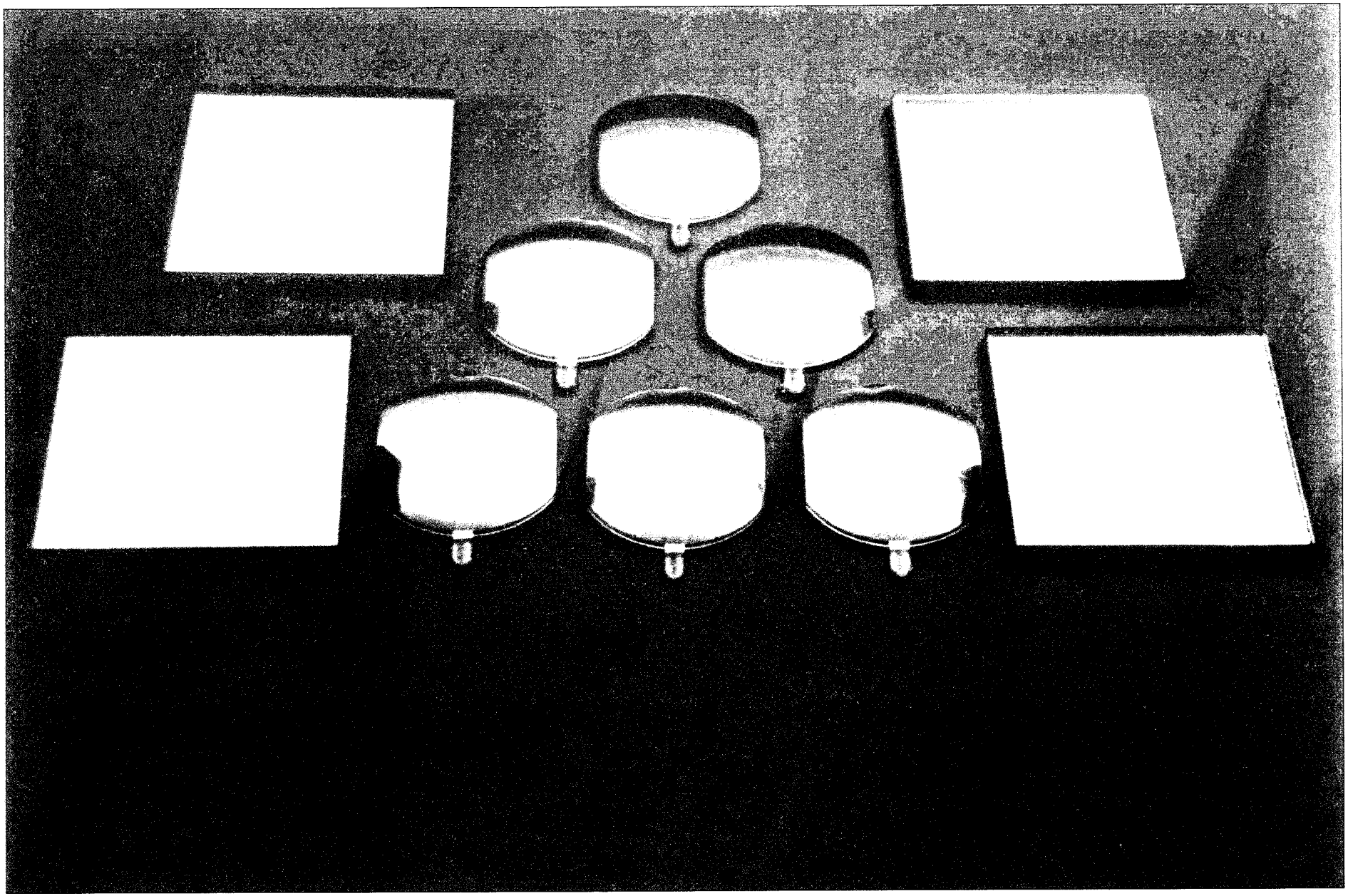
The NTSED device employs a non-thermal advanced oxidation technique that efficiently exploits the unique characteristics of plasmas (gases with "free" electrons) to destroy hazardous waste associated with munitions development and disposal, as well as other gaseous and liquid pollutants. This unique waste treatment technology can be used to destroy hazardous compounds resulting from combustion processes that are of concern to both the Air Force and industry.

Accomplishment

The Armament Directorate's Weapons Flight Mechanics Division has designed, fabricated and tested a NTSED device used to destroy hazardous compounds. Test samples comprised of 20,000 parts per million of trichloroethylene (TCE), a known ground water contaminant, were passed through the NTSED device at a flow rate of approximately one liter per minute. Results indicated a 100% destruction of TCE accomplished with only 5 watts of input power. The TCE was converted into harmless carbon dioxide and liquid acids (primarily chloroacetic and dichloroacetic acid).

Background

In response to the Air Force requirement for a "cradle-to-grave" acquisition cycle for munitions, the Armament Directorate developed an environmentally responsible in-house program to destroy hazardous wastes associated with munitions development and disposal. After surveying applicable technologies, a NTSED plasma processing technique was utilized to destroy hazardous compounds that are of concern to the Air Force. This system operates by flowing a gas mixture (comprised of oxygen,water vapor, and a small fraction of the element to be oxidized) between two electrodes isolated from the gas mixture by a dielectric material (currently glass). This gas mixture is exposed to a high frequency AC voltage (usually on the order of 500 Hz) which breaks down the gas, creating a plasma. Since the electrons in the gas flow are excited orders of magnitude more than the heavy particles, their temperature is hot (on the order of 50,000 °K). However, the temperature of the heavy particles which is the temperature of the gas flow, remains at room temperature, therefore the process is referred to as "Non-Thermal." The purpose of the glass used in the device is to prevent particles from the conducting surfaces from participating in the plasma. A side effect of using the glass is that the discharge is quiet compared to a direct discharge between two conducting plates, hence the term "Silent Electric Discharge." It has been demonstrated that the NTSED process can effectively and efficiently destroy complex "hazardous" molecules. Current incineration methods for munitions produce large amounts of both nitrogen oxides (NO_x) and carbon monoxide (CO) which can be completely destroyed by augmenting the incineration system with this advanced oxidizing technique.



Rugate Filters Improve Optical Sensor Protection And Visibility

Payoff

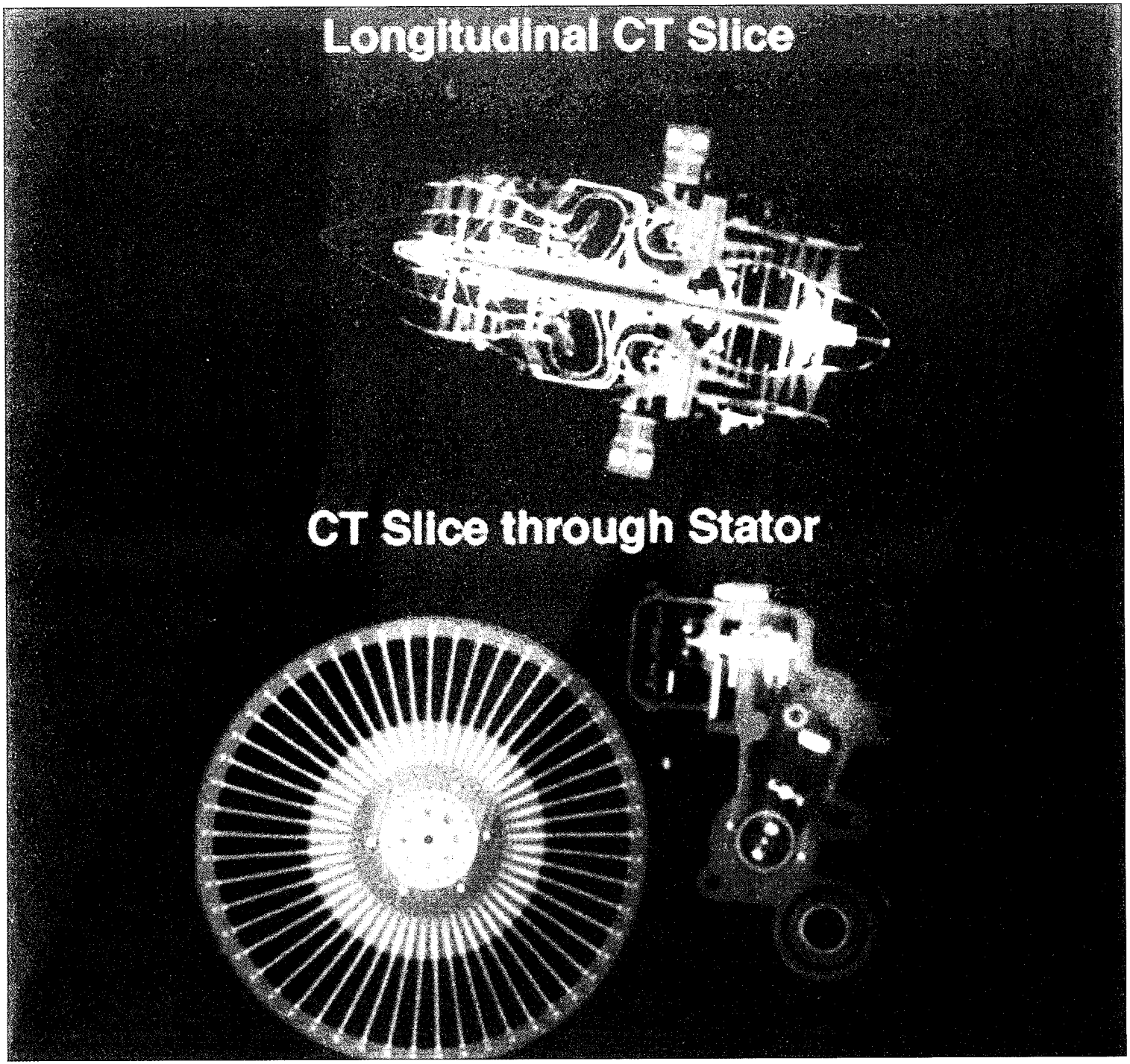
Unlike conventional optical coatings that offer limited design options, rugate filters permit unlimited design freedom for the manufacture of thin-film filters. Using rugate filters in sensor systems to replace conventional optical coatings will improve sensor performance with significant reduction in manufacturing costs. The development of rugate filters will enable the military to meet the optical performance specifications for advanced electro-optical systems.

Accomplishment

The concept of rugate filters was invented in-house by researchers in the Materials Directorate and has been successfully demonstrated as a practical approach for spectral filters for use in a broad class of optical sensors. This new class of optical filters was an outgrowth of military research in the Air Force's Wright Laboratory.

Background

Researchers in the Materials Directorate's Hardened Materials Branch have developed an unconventional, automated process that produces better, more flexible rugate optical filters. They have pursued this technology for over 10 years. The term "rugate" comes from the Latin word that means wrinkle because the index of refraction for these filters varies in an undulating or wave-like fashion. Rugates differ significantly from conventional optical filter technologies that require the deposition of discrete layers of optical materials. Future communication, optical detection and guidance needs of the Department of Defense (DOD) and electro-optical products of the United States industrial base require the use of specialized narrow bandstop and tailored bandpass optical filters. At the present time only rugate technology provides an inexpensive, yet high quality means of manufacturing these critical components. Rugate thin films have been fabricated that possess precise, single or multiple reflection/transmission bands placed at any position desired by the film designer. The designer now has complete freedom to tailor the width and shape of these bands. Several current and planned DOD systems are dependent on rugates to meet their mission requirements. Additionally, the new technology associated with the manufacture of rugate filters has been transitioned to industry to permit the manufacture of higher quality and lower cost optical coatings for many optical and electronic applications.


Longitudinal CT Slice
CT Slice through Stator

X-Ray Computed Tomography (CT) Proven Effective

Payoff

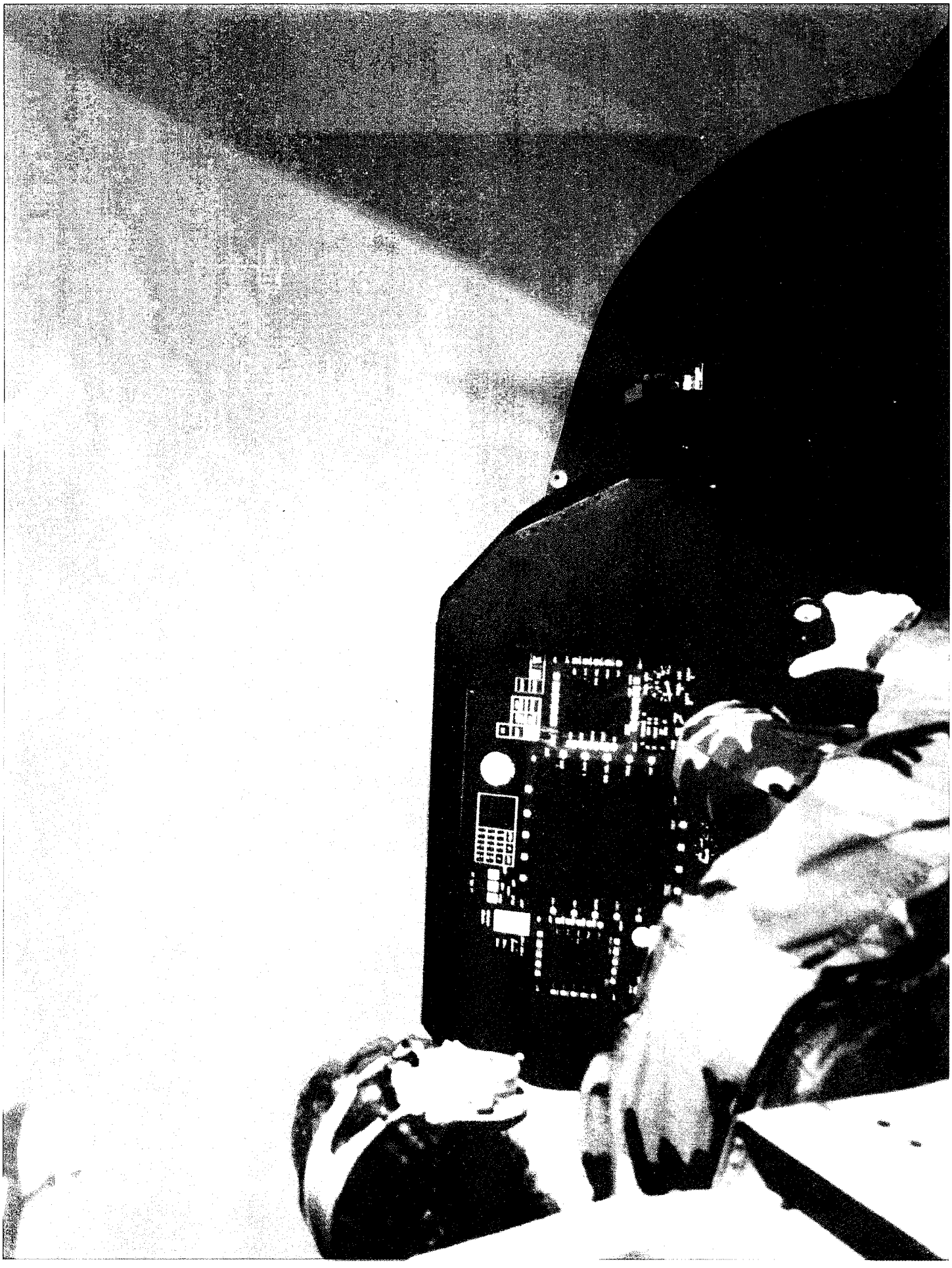
The X-ray Computed Tomography Applications Demonstration (CTAD) program, sponsored by the Materials Directorate, provided government and industry with a basis to determine how and where CT can be economically applied as a tool in the development, manufacture and maintenance of products. It also demonstrated the use of CT in a variety of applications (e.g. the Cruise Missile engine shown left) that had not been previously explored. Information learned in this program may help shorten development cycles for new products, provide accurate dimensional information for complicated structures and evaluate materials/components integrity in a very exacting manner.

Accomplishment

Under a program sponsored by the Materials Directorate, the Boeing Defense and Space Group demonstrated the utility and potential economic savings for the application of X-ray (CT) for a variety of materials and components. This advanced development of the CTAD program proved CT has economic value as an engineering tool in the inspection, development, evaluation and control of materials, components and manufacturing processes in a variety of government and industrial applications.

Background

It is important that new components and systems used to prolong the service life of the Air Force's fleet of aging aircraft be reliable and free of defects when fielded. One tool that can provide effective nondestructive evaluations, both during product development and after the product is put into service, is X-ray CT. In CT, a detector array measures the transmitted intensity of a thin fan beam of radiation passing through an object. A cross-sectional planar view of the object is obtained by reconstructing the intensity data collected from views obtained from all directions about the object. The data is digitally processed to reconstruct an image of the object's interior, providing dimensional and material characteristics. When multiple slices are taken over the entire part, a complete three-dimensional rendering can be formed. CT, originally conceived in the 1960s, was first used in hospitals with limited availability to applications outside the medical field. The Nondestructive Evaluation Branch of the Materials Directorate started the CTAD program in 1988 to evaluate non-medical applications for which CT is technically feasible and economically viable. CTAD results concluded that CT could prove effective in engineering applications, such as geometry acquisition, reverse engineering, failure analysis, performance prediction and prototype evaluation. It also benefits manufacturing applications, such as process development, configuration control, feature/anomaly location and engineering criteria acceptance. CTAD showed that CT has already been applied with proven cost savings to electronics, closed systems, castings and organic matrix composites. Literary documentation thoroughly details the investigations into 16 task areas with additional reports on "Geometry Acquisition" and "A Guide To CT Specifications."



Participation In The World's Largest Distributed Interactive Simulation

Payoff

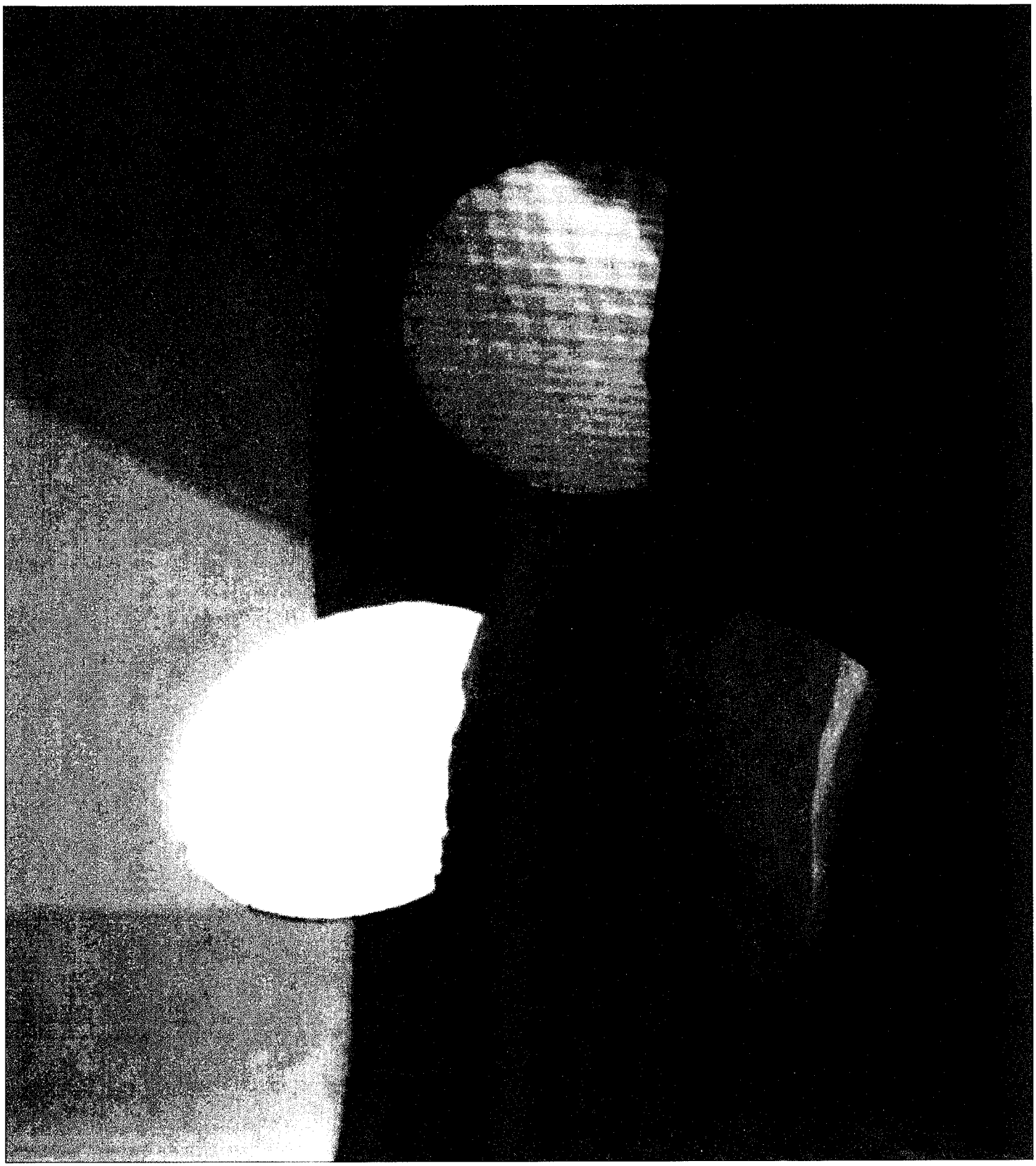
Imagine creating a huge virtual reality battlefield (using simulators around the country) that can be used to determine if a new technology will provide the winning edge, or if a reduced aircraft buy will impact readiness, or if pilots working together can defeat the hottest enemy aircraft around. Wright Laboratory, working in conjunction with the Advanced Research Projects Agency (ARPA), is making this vision a "reality".

Accomplishment

By participating in the world's largest distributed interactive simulation, the Flight Controls Division of Wright Laboratory's Flight Dynamics Directorate was able to play a part in supporting a new application of simulation. In addition, Wright Laboratory was a key participant in this simulation of over 5400 individual combatants by providing the only manned threat aircraft.

Background

The Control Integration and Assessment Branch of the Flight Control Division has worked with ARPA to link its simulators with other simulators located around the country, to create a huge virtual reality battlefield. This cooperation permitted Wright Laboratory the opportunity to contribute technically to the creation of these links which use long-haul networks. The link with Wright Laboratory's simulators was essential because of their capabilities in the area of manned aircraft. After three months of intensive engineering work, the extensive simulation software at Wright Laboratory was modified to interface with the input and output of other simulators. The result of this intense labor was the successful engagement in the simulated battle held 1-10 November 1993. Wright Laboratory played a key role by providing realistic, aggressive air-to-air (four manned Mig-29s) and air-to-ground (two manned F-15Es) combat aircraft. In addition to these manned aircraft, four digitally generated MiG-29s were also provided. During the simulation, Wright Laboratory's aircraft flew in combat against opponents from California to Virginia, creating the largest distributed interactive simulation in history. With over 5400 individual combatants on the network at one time, Wright Laboratory scored over 100 "kills" of opponent aircraft and destroyed approximately 20 ground-based mobile missile launchers during the simulated engagement.



Small Business Innovation Research (SBIR) Production Technique Will Increase Supply Of Single Crystal Silicon Carbide Wafers

Payoff

The new production technique for single crystal silicon carbide (SiC) wafers will clear the way for development of SiC based electronic devices which will triple the maximum operating temperature of electronics for future military and commercial systems. It will strengthen the position of the United States as the world leader in SiC materials technology and ensure an available source of SiC wafers for Air Force and commercial electronic applications.

Accomplishment

A SBIR effort, sponsored by the Materials Directorate, has led to the development of a manufacturing process that will increase the availability of high-quality single crystal SiC semiconductor wafers. In less than two years, with Materials Directorate researchers providing characterization and analysis support, Advanced Technology Materials Incorporated (ATMI) of Danbury CT has taken the technology from basic research to a production scalable process.

Background

Air Force systems are demanding more and more from electronic devices: improved performance, reduced size and higher reliability. Higher power microwave devices are required for next generation radar systems. A material that can help the Air Force meet these challenges is single crystal SiC. It is a rugged, wide band-gap semiconductor material that can maintain semiconducting performance at temperatures up to 600°C, about 400°C higher than other materials considered for such applications. The use of SiC technology is limited by the availability of good quality, reasonably priced wafers. Through the SBIR program, the Materials Directorate awarded a contract to ATMI in 1992 to develop a practical process for the production of high-quality, bulk SiC. ATMI developed a modified sublimation reactor which allows for controlled, repeatable growth conditions. High-quality wafers, with sizes up to one and one-half inches, have been produced. As good quality wafers become more available, a substantial increase in applications research will result, allowing the benefits of SiC to be exploited for many new technological areas. SiC devices are under development for on-engine jet sensors, blue/violet light emitting diodes (LEDs), integrated circuits, high-power X-band radar, sensors for the nuclear power industry and high-temperature electronics for use in automobile engines. The technology supports the Air Force's Integrated High Performance Turbine Engine Technology (IHPTET) and More Electric Aircraft (MEA) programs.

The Scholar's Companion Benefits Materials, Medical Community

Payoff

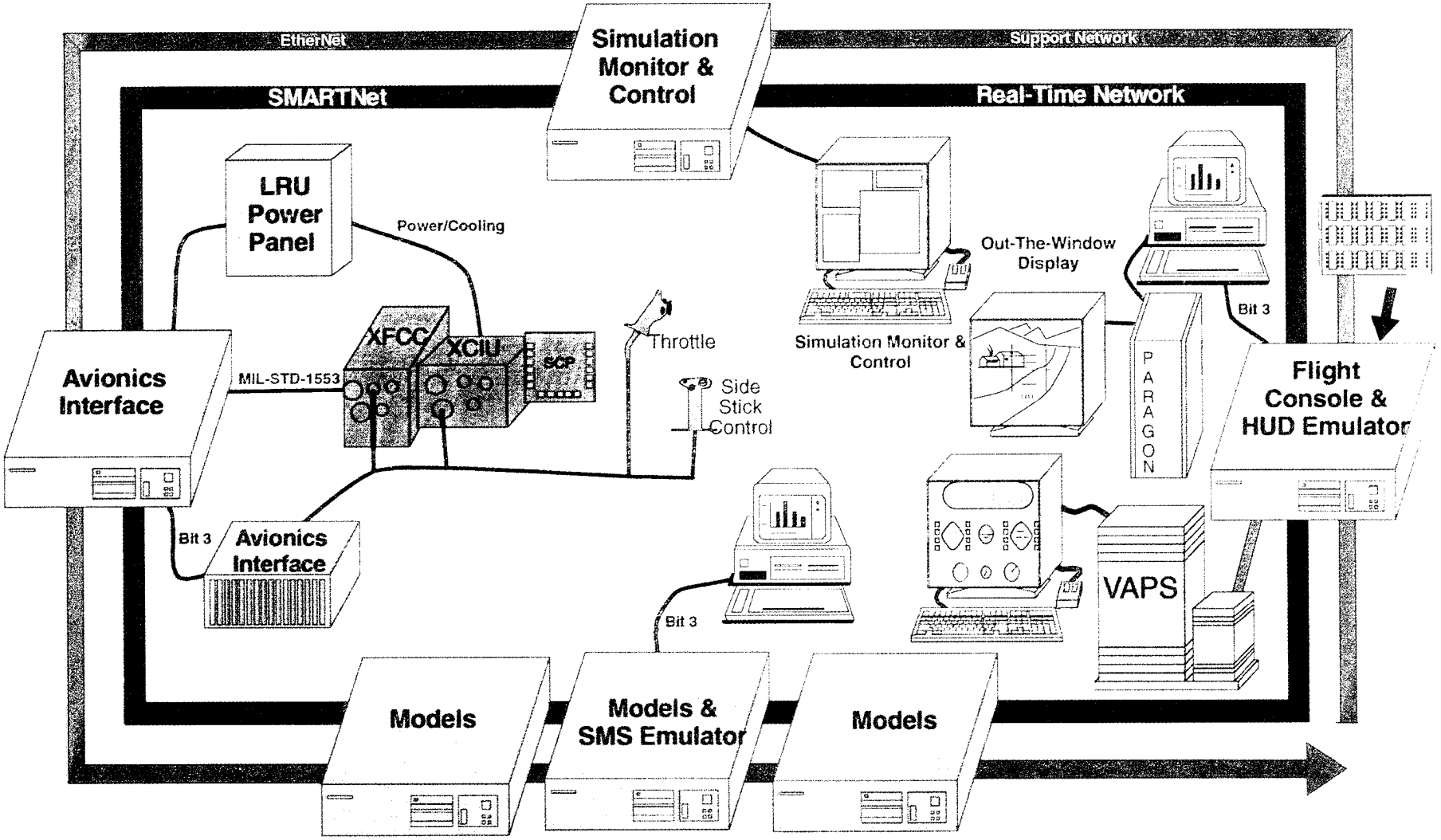
The Scholar's Companion (TSC) promises to be an important artificial intelligence research tool for developing methods to assist the body's natural healing process. Originally conceived for use in the development of materials process models, TSC will be used to create and refine scientific discovery models, so improvements can be made in experimental medical research. The combination of university and Air Force research using TSC will also speed the development of treatments for wounds, burns, infections, inflammation and human immune system deficiencies.

Accomplishment

A collaborative effort between the Materials Directorate and ThinkAlong Software Incorporated to develop materials process models is also contributing to medical research. Their cooperation, through a Small Business Innovation Research (SBIR) project, led to the development of TSC. This artificial intelligence tool is being used by both UCLA Medical School and the USAF Medical Center at Wright-Patterson Air Force Base, to help medical researchers find ways to assist the body's immune system in healing wounds faster and with less complications.

Background

The medical community has long used research-based models to investigate the human body's natural processes and seek potential cures for injuries and disease. One area that has required a new modeling strategy is the study of the immune system and its ability to fight infection and contribute to healing. A modeling strategy, or tool, that fits this need is TSC. This tool was developed for the Materials Directorate under a SBIR project by ThinkAlong Software of Brownsville CA. It was originally conceived for use in the development of materials process models, but has also become the focus of a collaborative effort between the Materials Directorate and the Hyperbaric Medicine Department at Wright-Patterson's USAF Medical Center. The Medical Center is developing a biological knowledge base to simulate the molecular composition of human cells, their internal processes and their interactions with each other and their environment. Emphasis is on the human immune system and processes by which it performs functions such as healing. TSC will be used to translate biomedical research literature into a model and a process to define and optimize biomedical experiments and medical interventions related to immune system dysfunction. Experimental results will provide feedback to the model and TSC will continually fine-tune it using artificial intelligence techniques.


EtherNet
Support Network
SMARTNet
Real-Time Network
Simulation Monitor & Control
LRU Power Panel
Power/Cooling
Out-The-Window Display
Bit 3
XFCC
XCIU
SCP
Throttle
Simulation Monitor & Control
Avionics Interface
MIL-STD-1553
Side Stick Control
PARAGON
Flight Console & HUD Emulator
Bit 3
Avionics Interface
Bit 3
VAPS
Models
Models & SMS Emulator
Models

Advanced Multi-Purpose Support Environment (AMPSE) Upgrade To F-16A/B Software Test Stations

Payoff

Traditional avionics software test stations are extremely expensive, inflexible and manpower intensive to operate. The F-16A/B version of the AMPSE, developed by Wright Laboratory's Avionics Directorate, addresses these problems. By employing a real-time network, multiple commercial computers and the Ada programming language, approximately $10 million in reduced acquisition and maintenance costs has been achieved after implementation at Ogden Air Logistics Center (OO-ALC).

Accomplishment

The Avionics Directorate's System Avionics Division has developed an F-16A/B version of the AMPSE simulation architecture for operational support of F-16A/B software. The ability of the AMPSE to support multiple F-16A/B software versions and multiple avionics computers, reduced the number of test stations required.

Background

Real-time avionics simulation has been an expensive requirement for avionics software development and test. Large facilities are generally required along with specialized equipment and the simulation environment is usually different for each aircraft. The software testing process is also very manpower intensive. The AMPSE architecture, produced in-house by Avionics Directorate engineers, was designed to alleviate these problems by cutting down on acquisition, maintenance and manpower costs associated with the simulation environment and testing. This simulation architecture uses a series of networked commercial off-the-shelf computers to perform the main simulation processing. The approach features a modular object-oriented design and extensive use of the Ada programming language to further decrease the system support costs. The AMPSE also provides automated testing, thus reducing the extensive demand upon manpower resources. OO-ALC is responsible for maintaining the software for the main computers on the F-16A/B. OO-ALC 's older simulation test stations had become increasingly expensive to enhance and maintain, and have also become a bottleneck in the test process because the overall time to test has increased. These manpower intensive test stations require manual operations to initialize the system, conduct the test and analyze the results. In support of OO-ALC, Directorate engineers proposed a new test station based on the AMPSE architecture that would reduce costs and required manpower. The initial operational capability of the F-16A/B AMPSE was delivered to OO-ALC in November 1991. The final capability for Engineering Release Testing of the F-16A/B Expanded Fire Control Computer Operational Flight Program was accepted in September 1992. A second phase, which added Expanded Central Interface Unit support was delivered in September 1993.

MULTI-AXIS THRUST VECTORING (MATV)
F-16 COMPLETES FLIGHT TESTING

Payoff

The MATV F-16 technologies not only offer a maneuverability and close-in combat advantage versus the standard F-16, but also signature and range improvements (by reducing tail surface requirements) and controllability improvements with asymmetric wing store loads. MATV will enhance the operability, performance, combat effectiveness/survivability, and flight safety of derivative and future aerospace weapons systems. The MATV hardware and software is readily retrofittable to digital flight control equipped F-16s.

Accomplishment

The Flight Dynamics Directorate's MATV Program Office completed flight testing of the MATV F-16 on 15 March 1994 at Edwards AFB. Milestones accomplished included: stabilized flight at 83 degrees angle-of-attack, dynamic maneuvering from plus to minus 180 degrees angle-of-attack, pitch and yaw rates up to 50 degrees per second at flight conditions where the elevator and rudder are ineffective, routine execution of post stall maneuvers (such as Cobra and J-turn), and near flawless engine operations at extreme attitudes and rotation rates.

Background

In May 1992, the Flight Dynamics Directorate initiated the MATV Program to flight demonstrate high angle-of-attack maneuverability benefits and evaluate the tactical utility of integrated pitch and yaw thrust vectoring on a fighter aircraft. The MATV nozzle hardware and controls, and the integrated flight/propulsion control laws for the system's use in an F-16, were developed by General Electric and Lockheed respectively. When a planned flight test by a foreign customer fell through, Wright Laboratory stepped in to sponsor a MATV flight test program at Edwards AFB, with the Air Force Flight Test Center as the Responsible Test Organization. Wright Laboratory provided the Variable-Stability Inflight Simulator Test Aircraft (VISTA) F-16 as the testbed, and paid for ground and flight testing after contractor funded aircraft modifications were completed. The inaugural MATV flight was made at Fort Worth on 2 July 1993. The first of 87 flights at Edwards AFB was made on 23 July. In all, 95 flights and 136 hours were logged in the MATV configuration. The MATV program pioneered new regimes for controlled, departure-free flight. The program's main goal, an evaluation of thrust vectoring's military utility, was accomplished by operational test pilots from Nellis AFB. The MATV technology is a potential candidate for future programs such as the Innovative Technology Integration Demonstrator.

A Faster, Cheaper Process for Making Ceramic Composite Components

Payoff

The Forced Chemical Vapor Infiltration (FCVI) process has enabled the fabrication of thick-walled ceramic composite components, such as the nine and one-half inch by five-eighths inch thick turbine rotor disk shown left, in less than a week as compared to several months for the conventional process. This process represents a cost savings of over 800 percent. Potential applications include military and commercial aircraft engine components, heat recovery equipment, chemical reactor and process equipment, waste incineration components, biomedical parts and more. The analytical FCVI model has been transferred to six commercial companies.

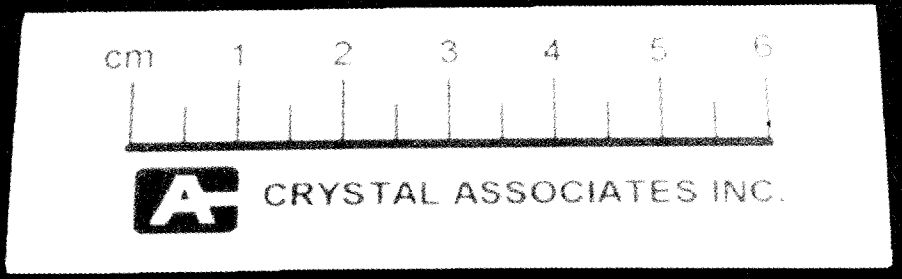
Accomplishment

Under a program jointly sponsored by the Materials Directorate, Oak Ridge National Laboratory and Georgia Institute of Technology, a process for making ceramic composite structures was demonstrated, modeled and scaled-up. This process can produce thick-walled components more quickly and at a substantially lower cost than the current commercial Isothermal Chemical Vapor Infiltration (ICVI) process with equal or higher quality.

Background

Conventional Chemical Vapor Infiltration (CVI) techniques for fabricating ceramic components, like ICVI, usually involve very long processing times, thus components which have thick sections ($t > 0.125"$) take a prohibitively long time to reach the required high density and low density gradient needed for high strength. Further, these components usually require several intermediate machining steps to reopen infiltration paths, which is very time consuming and costly. In order to overcome the shortcomings of ICVI, researchers at the Materials Directorate conceived a program which investigated isothermal as well as non-isothermal CVI processes. One such non-isothermal process is FCVI. A funded program was awarded to Oak Ridge National Laboratory, the inventors of the FCVI process, and Georgia Institute of Technology to develop analytical models of each process and validate those models with experimental results. The main advantages of the FCVI process is that infiltration can be done in much shorter times and part thickness is not limiting. FCVI involves the placement of ceramic fibers or cloths into a mold shaped to the component's geometry. Gas is introduced into the mold and travels in the free spaces between fibers. The mold is preferentially heated on one side and cooled on the other. The gas reacts and decomposes to a solid at the hot surface, thus closing the voids between fibers. The temperature gradient across the mold is adjusted until the component is uniformly dense, yielding a strong and tough ceramic composite material. FCVI increases the speed of infiltration as compared to the conventional process by directing the deposition site with the temperature and pressure gradients. Demonstrations have shown the FCVI technique can produce thicker (greater than one-eighth inch), tougher and more impact-resistant components in a practical manner. Further, they have shown that the process could be scaled to industrial-sized components.

RTA



Rubidium Titanyl Arsenate (RTA) Crystals Improve Performance of Solid-State Lasers

Payoff

The development of RTA crystals will increase the tunable range of military, industrial and medical lasers; improve communication networks and military aircraft warfare countermeasure systems; and make possible laser radar detection of atmospheric pollution sources. RTA will improve solid-state lasers by increasing laser power, while making laser operating frequencies tunable well into the infrared range. It will increase energy conversion efficiencies and eliminate many other shortcomings of conventional crystal materials.

Accomplishment

Scientists at the Materials Directorate and Crystal Associates Incorporated jointly developed an improved nonlinear optical crystal material that extends a laser's operating transmission range 15 percent further into the infrared than the conventional crystal material potassium titanyl phosphate (KTP). It also significantly reduces unwanted absorption of laser energy, has resistivity at least 10 times higher than KTP and exhibits no crystal damage with applied voltage. The material RTA , one of the derivatives of KTP, was developed through the Small Business Innovation Research (SBIR) program.

Background

Lasers are used today for a variety of purposes; from laser guided bombs for the military to laser surgery for the medical field and laser machining in the industrial sector, they have become commonplace. Currently the most popular solid-state laser (neodymium doped yttrium aluminum garnet [Nd:YAG]) usually generates light with a fixed wavelength of about one micron. To increase the power and wavelength variability of solid-state lasers, scientists have been seeking improved optical crystal materials to make better optical parametric oscillators (OPOs) and Q-switches. OPOs are used as a frequency tuner for the laser, while Q-switches are used to control release of the laser's energy. The materials currently used in the mid-infrared wavelength region for these components (KTP and lithium niobate) absorb too much of the laser's power, lose clarity as power increases, have high leakage current and decompose with applied voltage. Scientists at Crystal Associates Incorporated of Waldwick NJ, receiving financial support through the SBIR program and technical support from the Materials Directorate's nonlinear optical materials characterization facility, have developed several derivatives of the KTP compound that exhibit the characteristics needed to overcome the problems associated with conventional crystal materials. One such derivative, commonly referred to as RTA, has proven to be a promising material for OPO, modulation and Q-switch applications. OPO devices based on this crystal have proven to be reliable, solid-state sources of tunable laser radiation. Since the RTA-based material retains clarity as laser power increases, it extends the optical transmission range for OPOs and modulators further into the infrared range making the laser more versatile. The absorption of RTA is 10 times lower and it is far more resistant to electro-chemical decomposition than KTP.

KINETIC KILL VEHICLE HARDWARE-IN-THE-LOOP SIMULATOR (KHILS) REDUCES FLIGHT TEST RISK

Payoff

Because of the expense of flight tests and the risk associated with a flight failure, high fidelity ground test and evaluation capabilities have become critical to cost effective development of advanced guided missiles. KHILS provides a cost effective means for evaluating component and integrated missile system performance in realistic simulation scenarios prior to conducting expensive flight tests. Shown left is a target and background scene generated by KHILS.

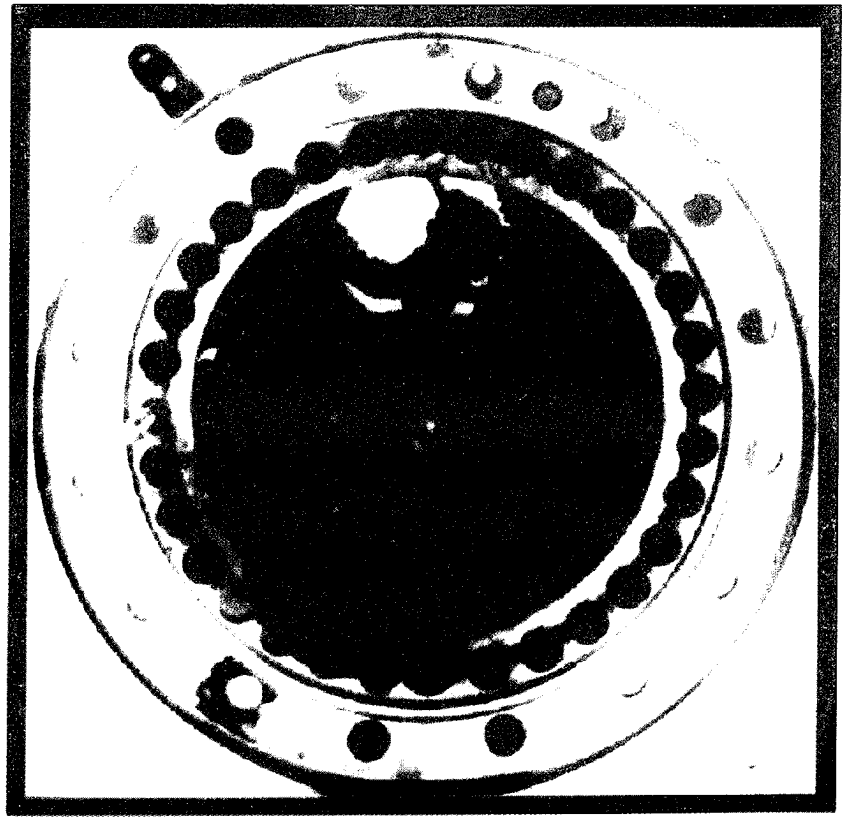
Accomplishment

The Armament Directorate has developed the capability to "fly" missile interceptor seekers through a complete simulated intercept and, for the first time in any facility, demonstrated a real-time closed loop hardware simulation for a theater missile defense concept. Together, the KHILS computer suite and physical effects simulators provide a unique capability to test detection, tracking and guidance of the guided interceptors being developed as theater and national missile defense systems as well as conventional air-to-air and air-to-surface munitions.

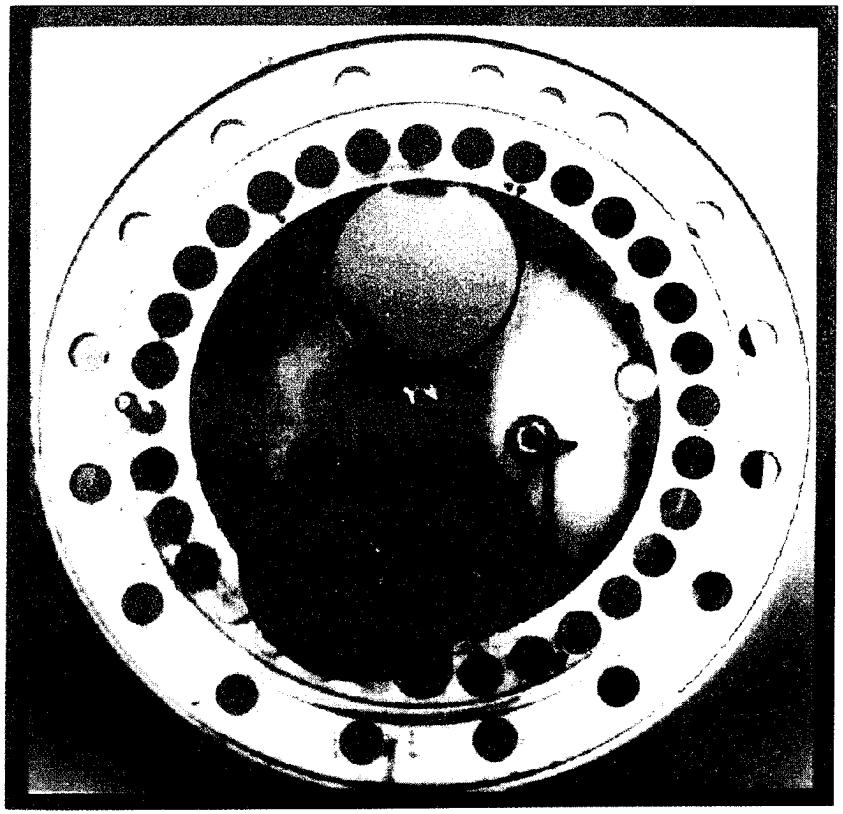
Background

KHILS supports a wide range of customers including weapon designers, developers, testers and users. The one-of-a-kind facility was initially constructed by the Air Force, in support of the Strategic Defense Initiative, to provide a high-fidelity ground test capability for guided interceptor systems. KHILS provides a unique capability to test and analyze the high performance system hardware (seeker, flight computer, inertial measurement unit, etc.) and on-board software (signal processing, guidance and autopilot algorithms, etc.) for guided interceptors and conventional guided munitions. The hardware and software can be "flown" as an integrated system concept, in a simulated mission, that includes all aspects of interceptor flight from launch to impact. Missile hardware that is not used in the simulation (i.e., propulsion) are included in the simulation through the use of high-fidelity computer models hosted on the real-time computers. KHILS represents an independent evaluation capability that supports government sponsored system development programs. It functions as an evaluation tool for program decision support, a flight test support tool to predict flight test performance and reduce the risk of test failure, a post-flight test analysis tool to reconstruct actual performance and as the interceptor component of an integrated battle management system simulator. All of the above capabilities are now available. They have been demonstrated in recent tests such as SEEDD (single and dual-bank detection discrimination and tracking), ULTRASEEK (aimpoint algorithm, automatic gain control, vibration compensation), SHaRRP (sensor handoff, discrimination target selection) and SIT (a system level test involving several linked facilities that simulated a complete interception with real time hardware-in-the-loop).

J57 ENGINE OIL SUMP AFTER 100 HOURS



MIL-L-7808J



MIL-L-7808K

New Improved Turbine Engine Lubricant

Payoff

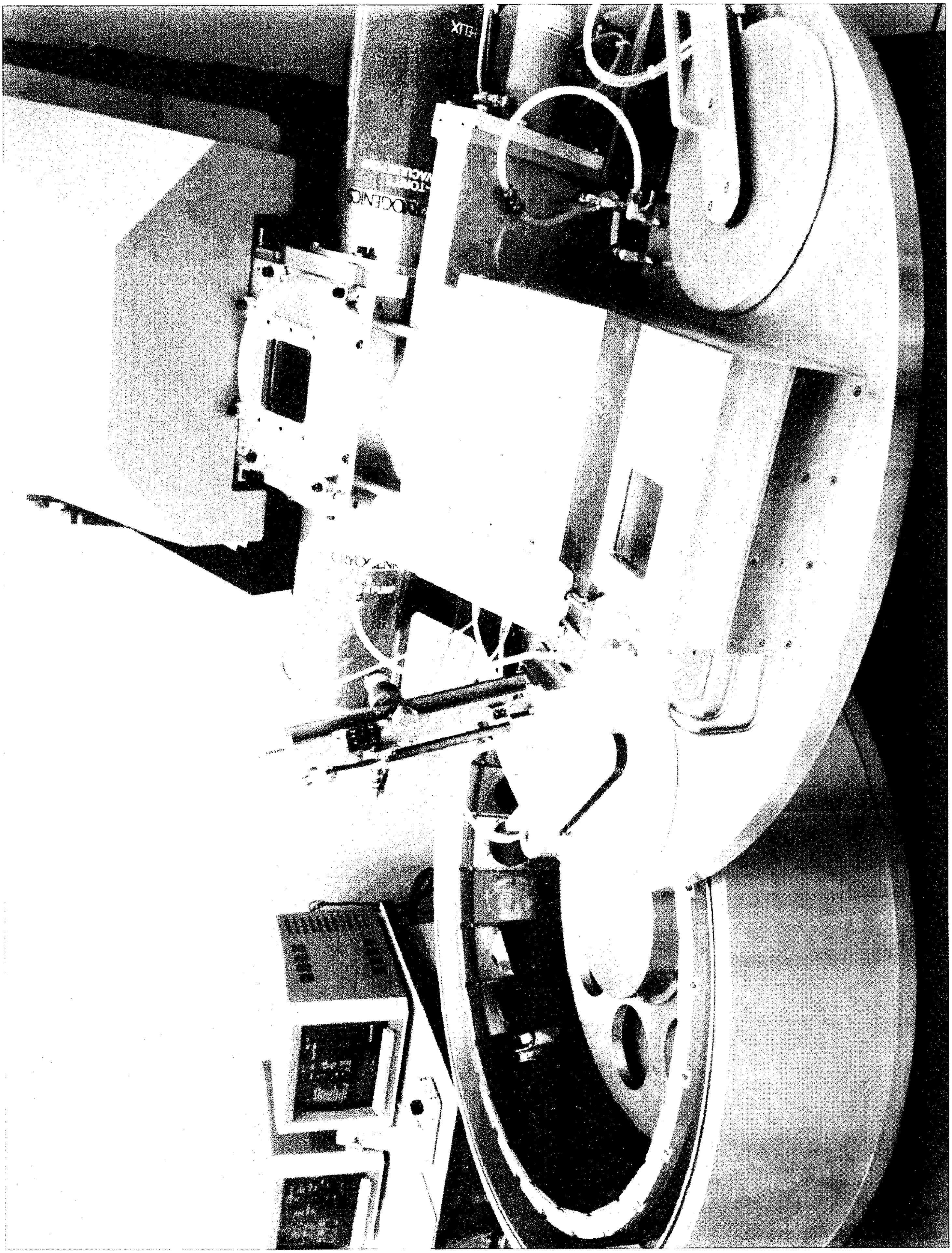
The new MIL-L-7808K 4 centiStoke (cSt) lubricant will offer greater thermal stability and reduced deposition tendencies (as shown left in the no. 6 sump of the J57 engine) for current and advanced aircraft that require high temperature lubricant performance. Reduced maintenance is envisioned for advanced engines which stress the lubricant with higher operating temperatures. It has already fulfilled the higher temperature requirements of the F-22's F119 engine.

Accomplishment

A new specification for Air Force turbine engine lubricants has been generated by the Aero Propulsion and Power Directorate, as a result of a joint program with the Materials Directorate. This new specification (MIL-L-7808K), requiring a viscosity of 4 cSt at 100° C, replaces MIL-L-7808J, which required a viscosity of 3 cSt at 100° C. The 4 cSt lubricant provides increased thermal oxidative stability and decreased deposit forming tendencies, while retaining low temperature pumpability.

Background

In order to provide worldwide, all-weather capability, Air Force turbine engine lubricants must be pumpable at -60° F. Due to the nature of synthetic lubricants, this requirement represses the high temperature capabilities. The Directorate recognized that a new lubricant formulation would be needed for advanced, higher performance engines, including the F119 engine in the F-22. Stringent target goals for the new MIL-L-7808K (4 cSt) lubricant were tailored through interfacing with the lubricant industry and the Advanced Tactical Fighter System Program Office (ATF SPO). Once convinced that the F119 engine would benefit from the higher performance lubricant, the ATF SPO authorized its use for F-22 prototype flights. Only one (of more than 30 candidates) 4 cSt lubricant has completed qualification screening evaluations thus far. This lubricant performed very well during F-22 prototype flights. Two additional candidates look very promising and may be qualified by early 1995.



SIMOX Wafer Technology Lowers Cost of Special Integrated Circuits

Payoff

Using the Separation by Implementation of Oxygen (SIMOX) approach, improved manufacturing processing techniques were developed that reduced the cost of producing silicon-on-insulator (SOI) wafers by 50 percent while assuring a supplier to the semiconductor industry. Utilization of an ion implanter, like the NV-200 ion implanter device shown left, to implant oxygen ions into a silicon wafer provides the capability to implement bipolar circuits and complementary metal oxide semiconductor circuits on the same integrated circuit chip.

Accomplishment

Under a program sponsored by the Manufacturing Technology Directorate, advanced manufacturing processes for employing the SIMOX approach to fabricate complex integrated circuits were established at IBIS Technology, Danvers MA, an independent SOI wafer vendor. The improved processing techniques using this approach produced a complex 256K bit static random access memory device, that exceeded the program memory goal by 1600 percent (256K vs 16K) and wafer yields that exceeded the program goal by 700 percent (14% vs 2%).

Background

SIMOX is an SOI technique used to fabricate complex integrated circuits. The utility of SOI technology for application in military systems has been demonstrated in the past by silicon-on-sapphire (SOS) technology, which has been used in fabrication of radiation hardened metal oxide semiconductor integrated circuit devices. One of the primary disadvantages of SOS technology is that researchers using it have been unable to produce bipolar integrated circuits for application in military systems. SOS does not allow for growth of components and isolation between devices grown on the wafers. SIMOX technology, on the other hand, is a specific SOI approach that allows for the implementation of bipolar circuits, as well as complementary metal oxide semiconductor circuits on the same integrated circuits chip. SIMOX wafer technology implants oxygen ions into a silicon wafer to create a buried silicon-dioxide layer to enable the desired isolation of the metal oxide semiconductor and bipolar transistor circuits contained in the silicon layer above the buried silicon dioxide.

Panoramic Cockpit Controls and Displays System (PCCADS) Facility Enhances Pilot-Aircraft Interface

Payoff

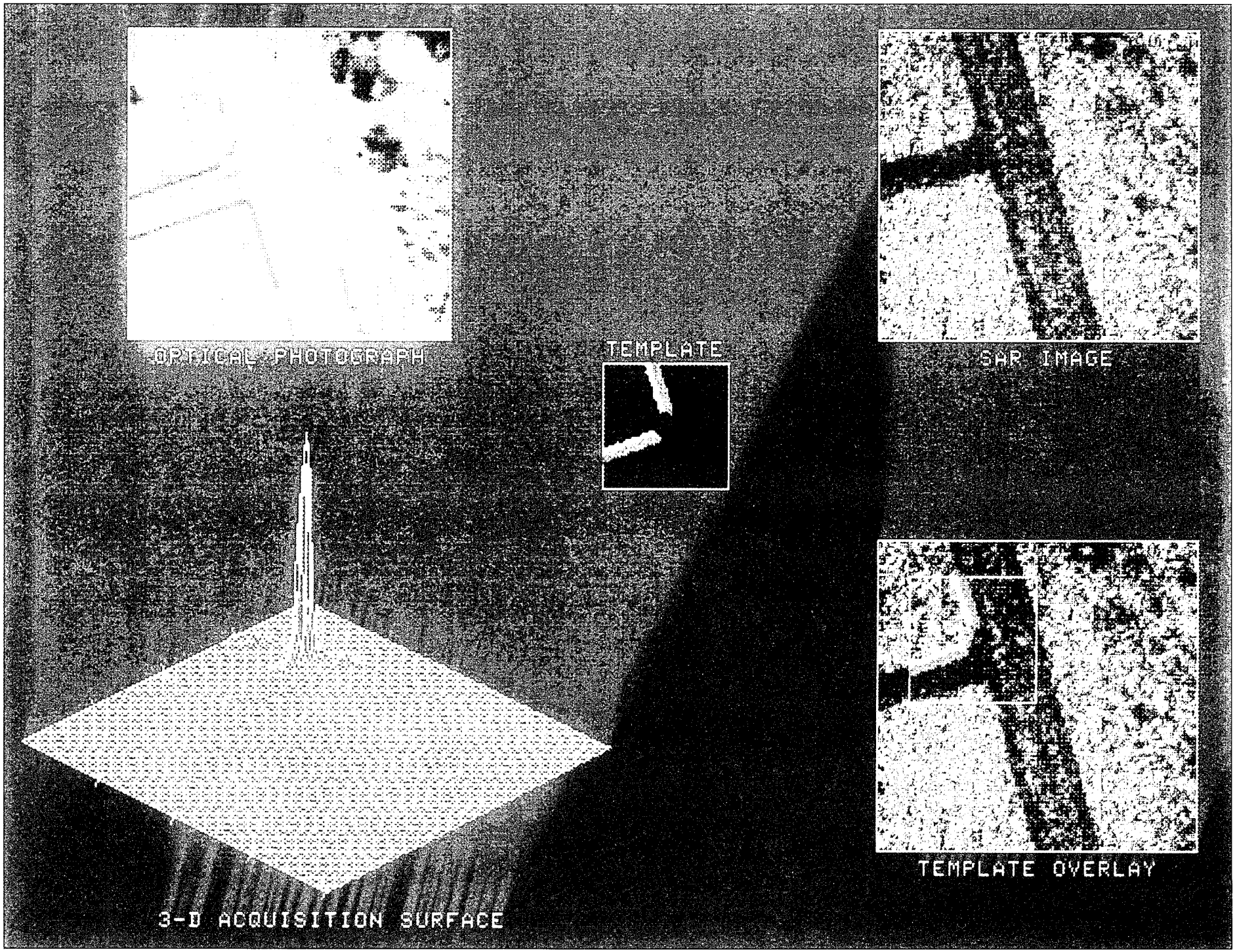
The PCCADS facility (shown left) has been converted from a cockpit demonstrator into a valuable tool for research. The results of connected-speech voice recognition tests conducted in this facility have been transitioned to the Army Rotocraft Pilot's and Tank Crew Associate program and the Air Force Education and Training Command program. This transition has the potential for eliminating two years of research for each program and overcoming expensive fighter trainer program shortfalls.

Accomplishment

The Flight Dynamics Directorate's Cockpit Integration Division successfully achieved, in the PCCADS facility, connected-speech recognition that has been integrated with stereoscopic 3D displays and is 99 percent accurate for cockpit vocabularies. Innovative aircraft attitude indicators that aid in unusual-attitude aircraft recoveries have been developed.

Background

A "connected-speech recognizer" is a recognition system which can "hear" and "identify" strings of words put into a phrase by the speaker. In other words, instead of the user speaking to the computer one word at a time (i.e., "Select--the--air--to--ground--mode"), the operator can speak to the computer in normal sentences at a natural speech tempo (i.e., "Select the air-to-ground mode."). The advantage of the connected-speech recognizer is that it understands phrases as spoken in a human-natural manner. The PCCADS, built by McDonnell Douglas, is a unique cockpit evaluation system that is the basis for unusual-attitude aircraft recovery studies and provides a platform for advanced 3D cursor control, voice recognition, decision support, man/machine task allocation and situation awareness research. It is a flexible tool for the realistic testing of advanced cockpit control, displays and decision aids. The PCCAD's cockpit contains an 79 x 58 inch out-the-window display screen and a 29 inch CRT that can be flexibly formatted with multiple advanced cockpit displays, as well as, with current aircraft instrument suites for baseline comparisons. Voice recognition is achieved via an off-the-shelf International Telephone and Telegraph voice board for connected-speech. Decision support and intelligent crew aids are accomplished via a bank of Silicon Graphics, aircraft-compatible processors that are preprogrammed using the latest techniques in real-time graphics, expert systems and neural networks.


OPTICAL PHOTOGRAPH
TEMPLATE
SAR IMAGE
TEMPLATE OVERLAY
3-D ACQUISITION SURFACE

Synthetic Aperture Radar (SAR) Technology Transitioned

Payoff

SAR seeker imagery can be combined with target recognition algorithms to automatically find targets and locate aimpoints as shown left. The precision guidance offered by SAR seekers reduces the number and the size of air-to-surface munitions needed to achieve target kills as well as the number of aircraft sorties required, providing a "one target, one bomb" capability. The autonomous operation allows a "launch and leave" capability which reduces the pilot workload, minimizes exposure of the aircraft to hostile air defenses surrounding critical targets and expands the application of precision weapons to single-seat aircraft.

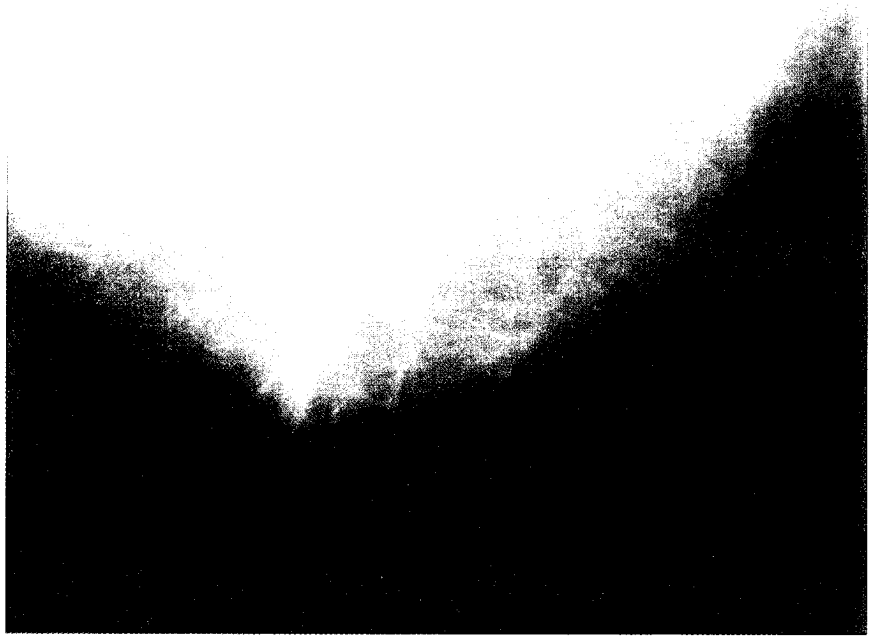
Accomplishment

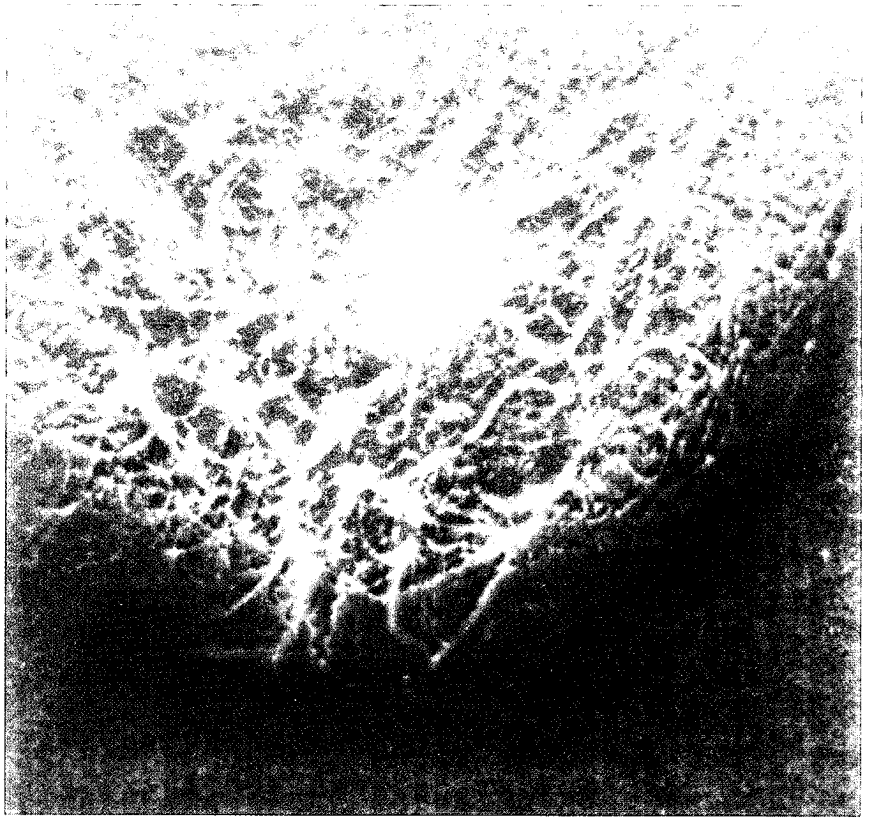
Results from flight test demonstrations of the guidance capability of SAR seeker technology, developed by the Armament Directorate, Raytheon Company of Boston MA and Loral Corporation of Phoenix AZ, under the Autonomous Synthetic Aperture Radar Guidance (ASARG) program have led to the incorporation of SAR seeker technology as a candidate precision guidance upgrade for the Joint Direct Attack Munition. In an extensive series of captive flight tests, SAR seekers demonstrated autonomous, all-weather, precision guidance of air-to-surface munitions against a variety of targets including bridges, industrial facilities, military installations and armored vehicles. These seekers are unaffected by adverse weather conditions such as clouds, fog, rain, dust and battlefield smoke which prohibit the use of current electro-optical and infrared guided weapons.

Background

In December 1985, the ASARG program began by addressing critical affordability, performance and packaging issues of SAR seeker applications to conventional air-to-surface munitions. ASARG has successfully met performance challenges within a package less than 2 cubic feet in volume and suitable for application to Direct Attack Munitions, Stand-Off Weapons and Cruise Missiles. Affordability, which is a critical issue for the feasible application of SAR guidance, has been addressed throughout the ASARG development. Since the early 1980s, ASARG has reduced the potential production cost of SAR seekers from $450,000 to less than $30,000. ASARG has also greatly simplified weapon targeting over that of current mission planning systems required by autonomous weapons such as cruise missiles. ASARG has the capability to use real-time battlefield intelligence information and process an entire target reference in less than three seconds, thus providing a capability to retarget even after the weapon has been launched. The robust mission planning capability developed by ASARG provides rapid target reference preparation and retargeting which will allow field commanders greater flexibility against critical targets and targets of opportunity.

Normal and wavelet transformed digital mammograms





Dual Use, High-Speed Image Processing

Payoff

The development of a low cost, high-speed (trillions of operations per second) image processing technology suitable for commercialization as well as military uses (all digital automatic target recognition for future autonomously guided weapon systems) will significantly lower the production costs of a potentially costly acquisition. By applying this level of image computational throughput, advanced mathematical methods can be applied, in real-time, to digital mammography for earlier detection of cancer in younger women.

Accomplishment

Technology developed by Wright Laboratory's Armament Directorate and the University of Florida will allow for improved speed of image processing up to several hundred times faster than the current state-of-the-art medical imaging. The technology couples the operational functionality of an image algebra with a parallel, single instruction, multiple data processor architecture. No known hardware/software combination will have the level of programmability and throughput performance over all image-to-image transformations.

Background

The Armament Directorate's in-house research on high-speed image processing architecture was initiated in 1991 and has resulted in two patents. In August 1992, when the National Cancer Institute (NCI)/NASA sent a Problem Statement to all Federal Laboratories requesting solutions to problems for digital mammography, the Directorate responded with their proposed technology for improving the speed of image processing. At a NCI/NASA Technology Transfer Conference in May 1993, the proposal was judged to be promising and its further exploration in the field of medical imaging was recommended. NCI endorsed the Armament Directorate's approach as a lead technology in August 1993. As a result, the Directorate is actively seeking cost sharing arrangements with Advanced Research Projects Agency, NASA and other government agencies.

Intelligent Tutor System (ITS) Benefits High School Students

Payoff

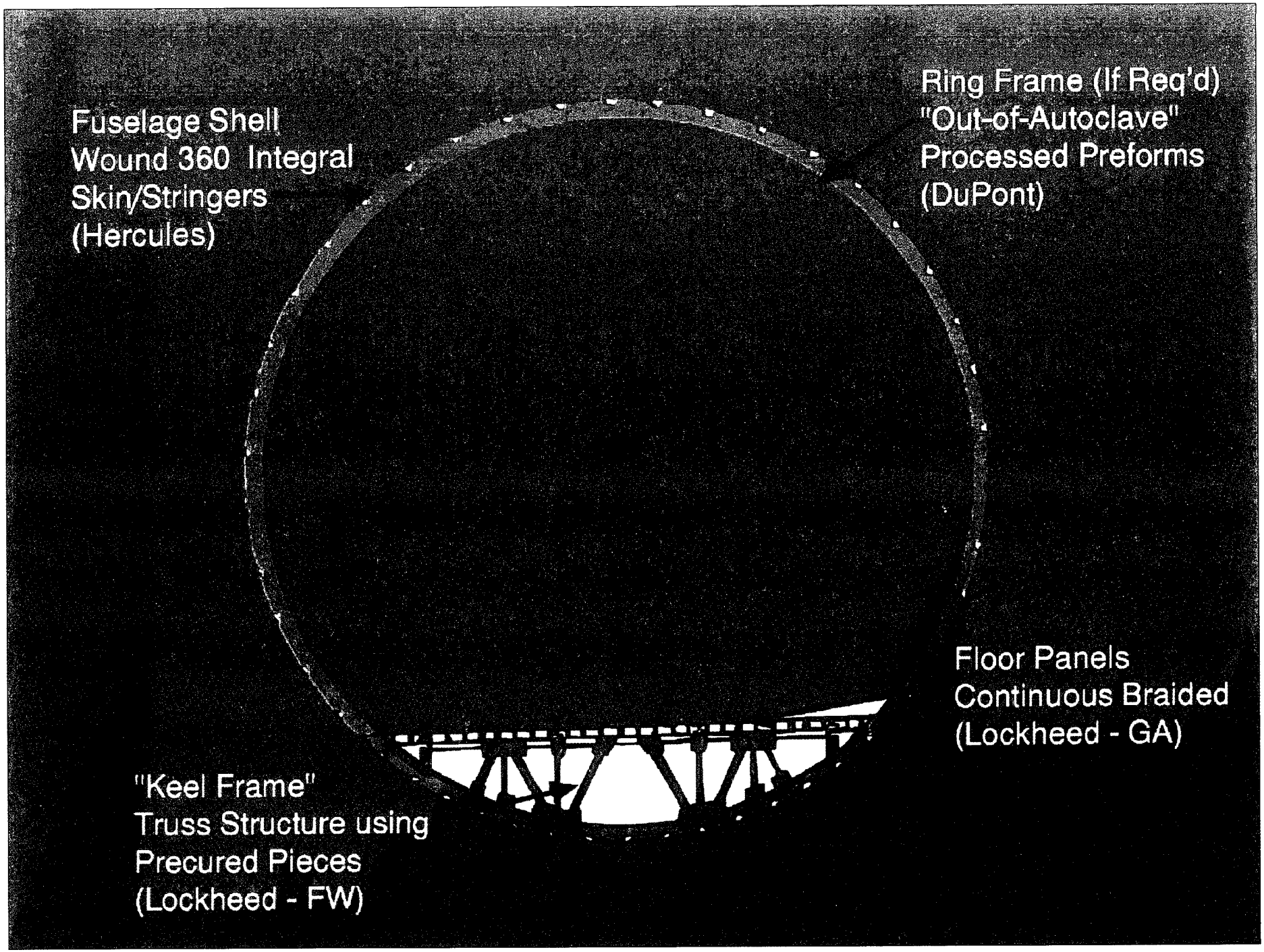
Dayton-area high school students in the Intelligent Tutor program have improved their score on the mathematics portion of the Ohio Proficiency Test. ITS is an effective teaching aid for teachers and increases student enthusiasm for learning. Feedback provided by the public school test sites will provide data to help improve ITS, as well as other Air Force computerized training programs. Partnering with a commercial vendor through a Cooperative Research and Development Agreement (CRDA) will improve ITS and make it available to educational institutions nationwide.

Accomplishment

Wright Laboratory and Armstrong Laboratory are introducing Dayton OH high school students to a new concept in computerized learning. A team approach, led by scientists in the Materials Directorate, is providing the resources needed to offer Armstrong Laboratory's ITS artificial intelligence software program at selected Dayton-area high schools. Students, using the Intelligent Tutor program that teaches word problem solving algebra, have improved their math score on the Ohio Proficiency Tests.

Background

The Air Force is pursuing the use of computers as tutors to aid in its training programs. Artificial intelligence-based software, called ITS, developed by Armstrong Laboratory, allows a computer to emulate a teacher, in the sense that such a system knows what to teach, how to teach it and who is being taught. The system increases the student-to-teacher ratio from six-to-one to 30-to-one without a decrease in learning and has the ability to adapt to each individual student's needs. It also expands a teacher's ability to provide individualized instruction and provides important feedback to students and teachers to enhance classroom instruction. Wright Laboratory entered into an agreement with Armstrong to test ITS in the Dayton area. It awarded a research grant to Dayton's Alliance for Education (part of the Dayton Foundation) to set up ITS computer laboratories at Dunbar and Trotwood-Madison High Schools. AT&T Global Information Systems provided 60 top-of-the-line computers to Wright Laboratory at cost and also provided installation and ongoing technical troubleshooting. The Engineering and Science Foundation of Dayton funded the remodeling of classrooms to make first-class computer labs. The program was active within five months of its inception in May 1992. The first completed software package, called the Word Problem Solving Tutor, teaches word problem solving algebra using word story problems. Teachers feel ITS allows them to work one-to-one with slower students while giving the other students the opportunity to work ahead. Tutors in English (reading and writing) and life science are currently under development. Armstrong Laboratory has entered into a CRDA with PWS, a division of Wadsworth Publishing Company, to further develop the software and market it commercially to school systems nationwide.


Fuselage Shell
Wound 360 Integral
Skin/Stringers
(Hercules)
Ring Frame (If Req'd)
"Out-of-Autoclave"
Processed Preforms
(DuPont)
Floor Panels
Continuous Braided
(Lockheed - GA)
"Keel Frame"
Truss Structure using
Precured Pieces
(Lockheed - FW)

Integrated Product Development Techniques Aid the Development of a Low-Cost Composite Transport Fuselage

Payoff

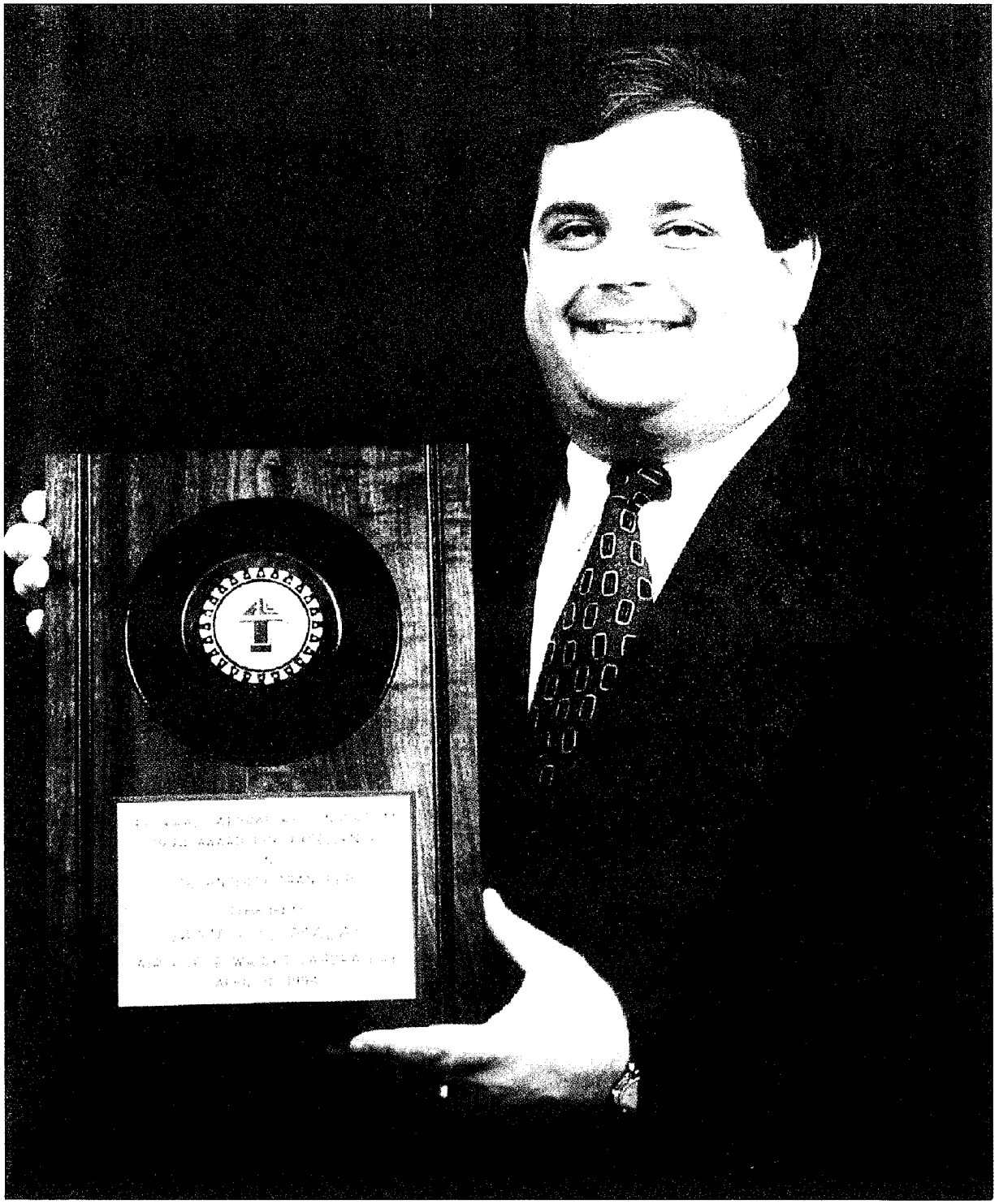
In the Design and Manufacture of Low-Cost Composites program, engineers used integrated product development techniques to develop a one-piece totally integral transport composite fuselage that reduced manufacturing costs by 61 percent and supportability costs by 58 percent when compared to a baseline fuselage. Future weapon systems will use advanced composite structures to meet increased performance and survivability requirements.

Accomplishment

Under a program sponsored jointly by Wright Laboratory's Manufacturing Technology and Flight Dynamics Directorates, a one-piece composite transport fuselage was designed using integrated product development techniques. Results exceeded the program's goals, which were to develop integrated design and manufacturing technologies to reduce acquisition costs associated with composite structures by 50 percent, while reducing supportability costs by 25 percent.

Background

Historically, there has been little opportunity to reduce the cost of advanced composite aircraft structures using existing technologies due to limitations in design concepts and methods, material properties and manufacturing processes. The Manufacturing Technology Directorate's Design and Manufacture of Low Cost Composites initiative sponsored four projects to research methods to reduce acquisition and ownership costs of composite structures. The fuselage program was a team effort headed by Boeing Defense and Space Group and included team members from Lockheed Georgia, Lockheed Fort Worth, Hercules and DuPont. An integrated product development team approach was used to ensure that all functional concerns received consideration early in the design of the fuselage. The 18-month effort began with the design of a YC-14 composite fuselage using today's technology and manufacturing approaches as a baseline. After analyzing more than 250 ideas, engineers decided to design four different advanced fuselages. Designs were drawn and accompanied by a detailed manufacturing and tooling plan. A composite cost model was used to calculate acquisition costs. A cost analysis and strategy assessment model was used to calculate supportability and life-cycle costs. The first of the four concepts required the assembly of four sections into the 20-foot diameter fuselage. A honeycomb approach with two 185 degree sections was used in the second concept design. Thermoplastic material was the basis for the third concept. In the fourth concept, a totally integral composite fuselage was designed as a single unit. This concept requires no fasteners and no major final assemble activities. The floor structure is built inside the fuselage section using truss members and gussets. Rod packs stiffen the fuselage stringer caps. This concept was selected as the most efficient of the four.



Award for Transferring Air Force Materials and Processing Technology

Payoff

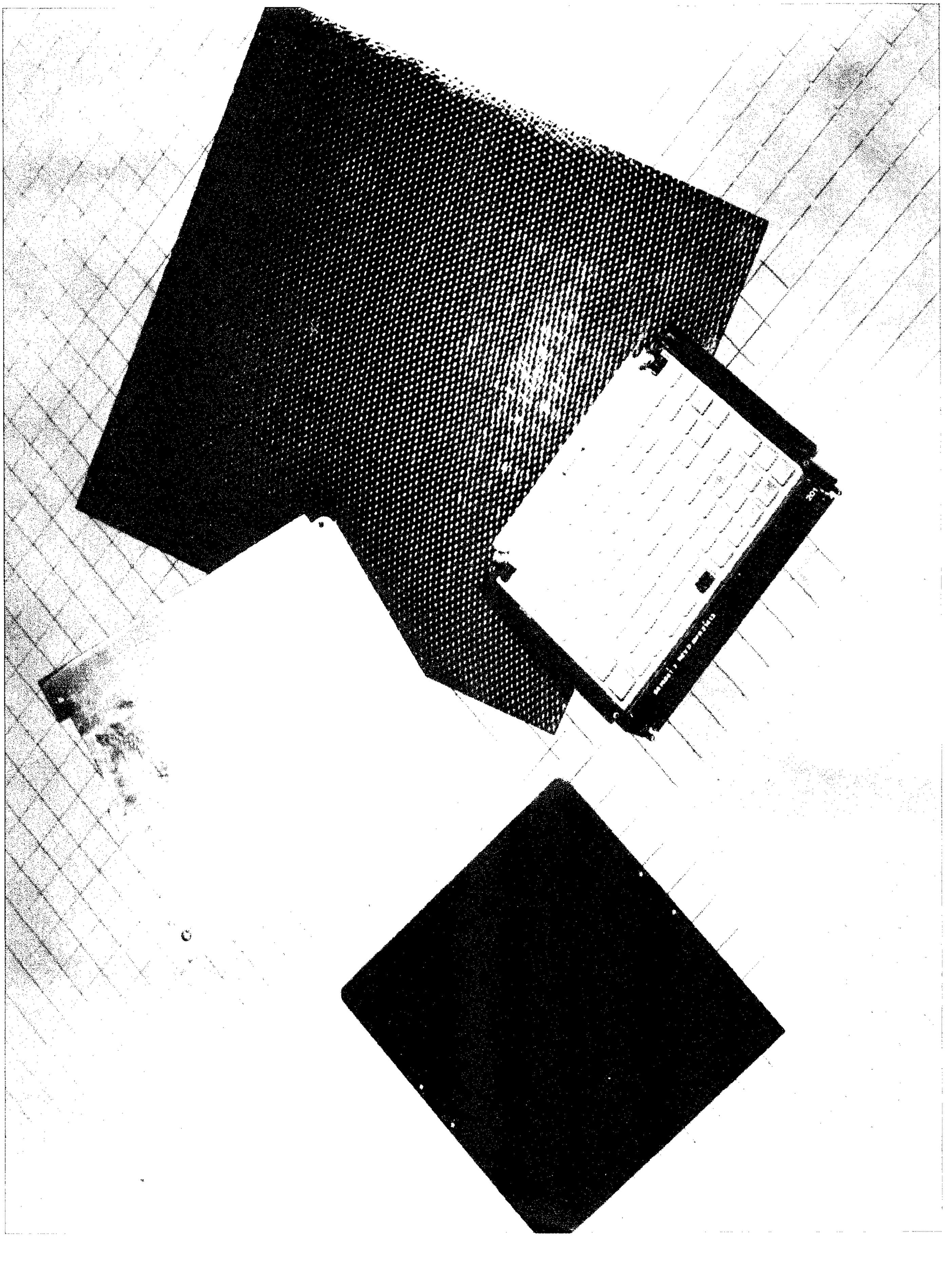
In recognition of Dr. James C. Malas's efforts to transfer the Materials Directorate's material extrusion models and process control technology to a network of aluminum extrusion and die-making companies in and around the Youngstown OH, area, he was presented a 1994 Federal Laboratory Consortium Award for Excellence in Technology Transfer. The extrusion companies involved have reported a 25 percent increase in productivity, a 40 percent reduction in start-up scrap material, and a 25 percent reduction in average extrusion costs.

Accomplishment

Dr. James C. Malas of the Materials Directorate's Materials Process Design Branch received a 1994 Federal Laboratory Consortium Award for Excellence in Technology Transfer for his achievements in transferring Air Force materials and processing technology in the form of software, data, material testing techniques and advanced process engineering procedures to the aluminum extrusion industry. The consortium's annual award for excellence in technology transfer is given to a select number of individuals who demonstrate their commitment by actively working to transfer a technology or process to the public or private sector.

Background

The Federal Laboratory Consortium for Technology Transfer is a network of over 500 federal government research and development laboratories and centers, representing 14 federal agencies. It was formed by Congress to help transfer technology from the federal laboratory system to commercial industry. The Consortium identifies and mobilizes the necessary resources to provide the environment, the organization and the technology transfer mechanisms required to facilitate the fullest possible use of federally sponsored research and development results by public and private sector potential users. Dr. Malas received one of three of the Consortium's annual awards presented to Air Force personnel in 1994. He led a team of scientists at the Materials Directorate in identifying and demonstrating proper materials and processing technologies, planning technology modification activities, and training process designers and technology developers. These activities and his personal involvement proved instrumental in developing aluminum extrusion modeling and process control technology that will save manufactures development cost and time in addition to improving their productivity, reducing scrap and reducing die trials and set-up time. His team worked with the Technology Development Corporation of Youngstown State University to transfer the material extrusion models and process control technology to a network of five aluminum extrusion and 16 die-making companies in and around the Youngstown area. This network produces domestic goods such as ladders, furniture trim, window frames, machine parts and bicycle rims.



Production Capability for Graphite Fibers Established Under Title III Program

Payoff

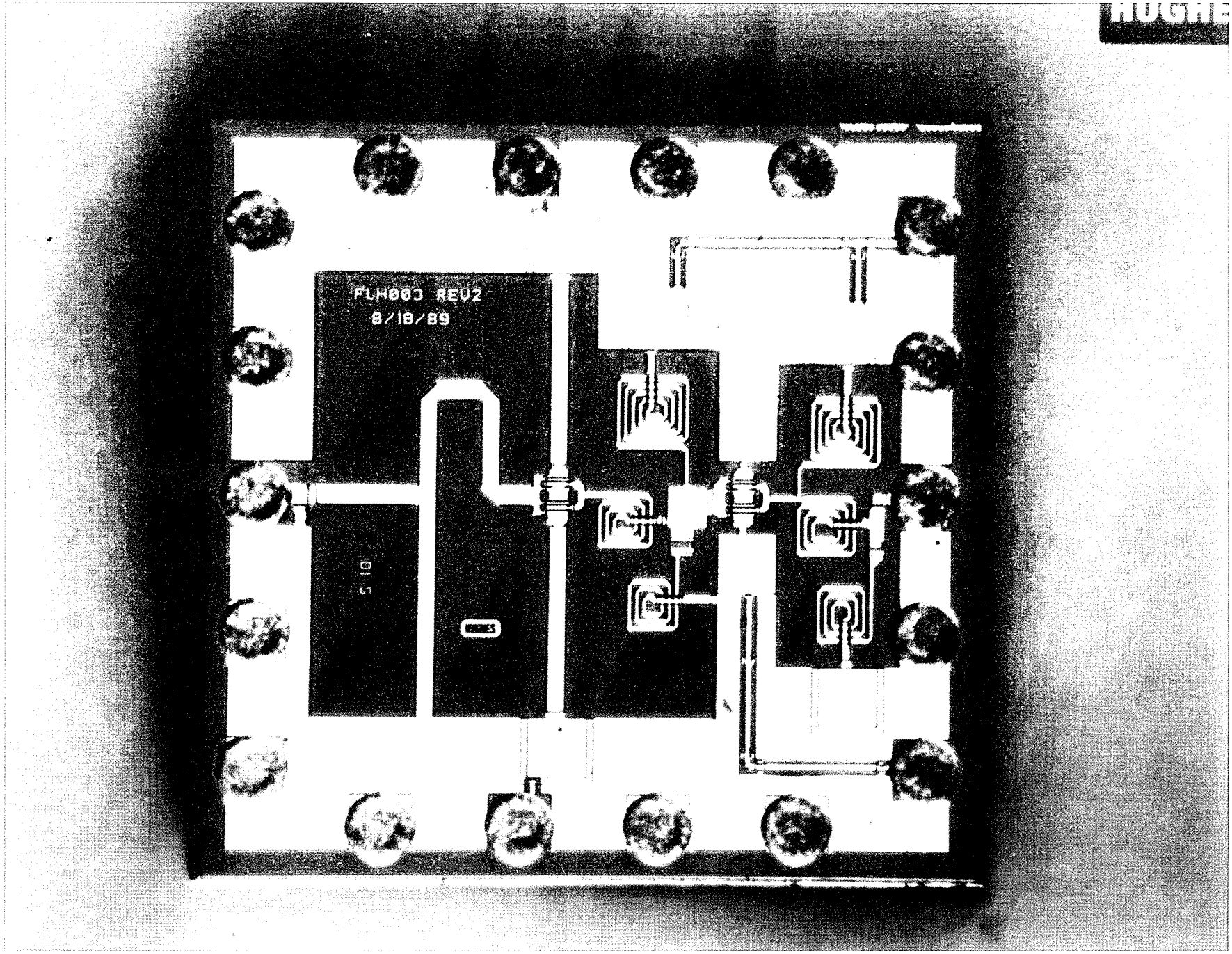
Amoco and Wright Laboratory have succeeded in establishing a domestic production capability of more than 10,000 pounds per year of world-class graphite fiber for military and commercial structural and thermal management applications. Graphite fiber produced as fabric for circuit board application is shown left. In conjunction with a Navy Manufacturing Technology (MANTECH) program, the program has also led to production of a new graphite fiber with enhanced strength and handleability properties.

Accomplishment

A program, sponsored by the Materials Directorate and managed by the Manufacturing Technology Directorate's Title III Program Office, successfully established domestic production capacity for high modulus pitch-based graphite fibers, which included reaching goals for production rates, sales and fiber strength improvements. Due to commercial sales of the graphite fiber, the Title III purchase requirement was reduced and saved the government $1.2 million.

Background

Prior to the Title III project, U.S. industry efforts to develop production capabilities for critical carbon fibers were lagging behind foreign producers. As a substitute for steel and aluminum, graphite fiber composites reduce weight by as much as 40 percent, increase stiffness, provide better thermal characteristics under high-temperature operating conditions, and offer greater resistance to fatigue and corrosion. These fibers are used in avionic heat sinks, aircraft engines, satellite antenna and optics structures and are being evaluated for numerous additional aircraft and spacecraft uses. The Title III Program provided the contractor, Amoco Performance Products Inc. of Greenville SC, a financial incentive to share the costs and risks of establishing the production capacity by committing to purchase up to 7,500 pounds of fiber. Graphite fiber sales by Amoco to defense and commercial users, however, reduced the Title III purchase by 2,400 pounds, saving taxpayers $1.2 million. Expanding the commercial applications of this fiber accounted for most of these fiber purchases, making it a dual-use product. Most of the fiber bought by the Title III Program has been provided as samples to industry. Companies such as BF Goodrich, Boeing, General Electric, Lockheed, Martin Marietta and McDonnell Douglas have each received over 50 pounds of fiber for evaluation and qualification. Universities and government laboratories have also been provided fiber. All of the major carbon fiber prepreg manufacturers have sample fibers to gain handling experience. A major technical advance in the Title III project occurred as a result of a Navy MANTECH effort to enhance the strength and improve the handleability of graphite fiber used for structural applications. This has led to the production of a graphite fiber (called P-100HTX) equal to or better than fiber produced anywhere in the world. The Title III office took possession of 50 pounds of this enhanced fiber and funded a Materials Directorate project to develop properties data for this fiber.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Improved Manufacturing Processes For Flip Chip Technology

Payoff

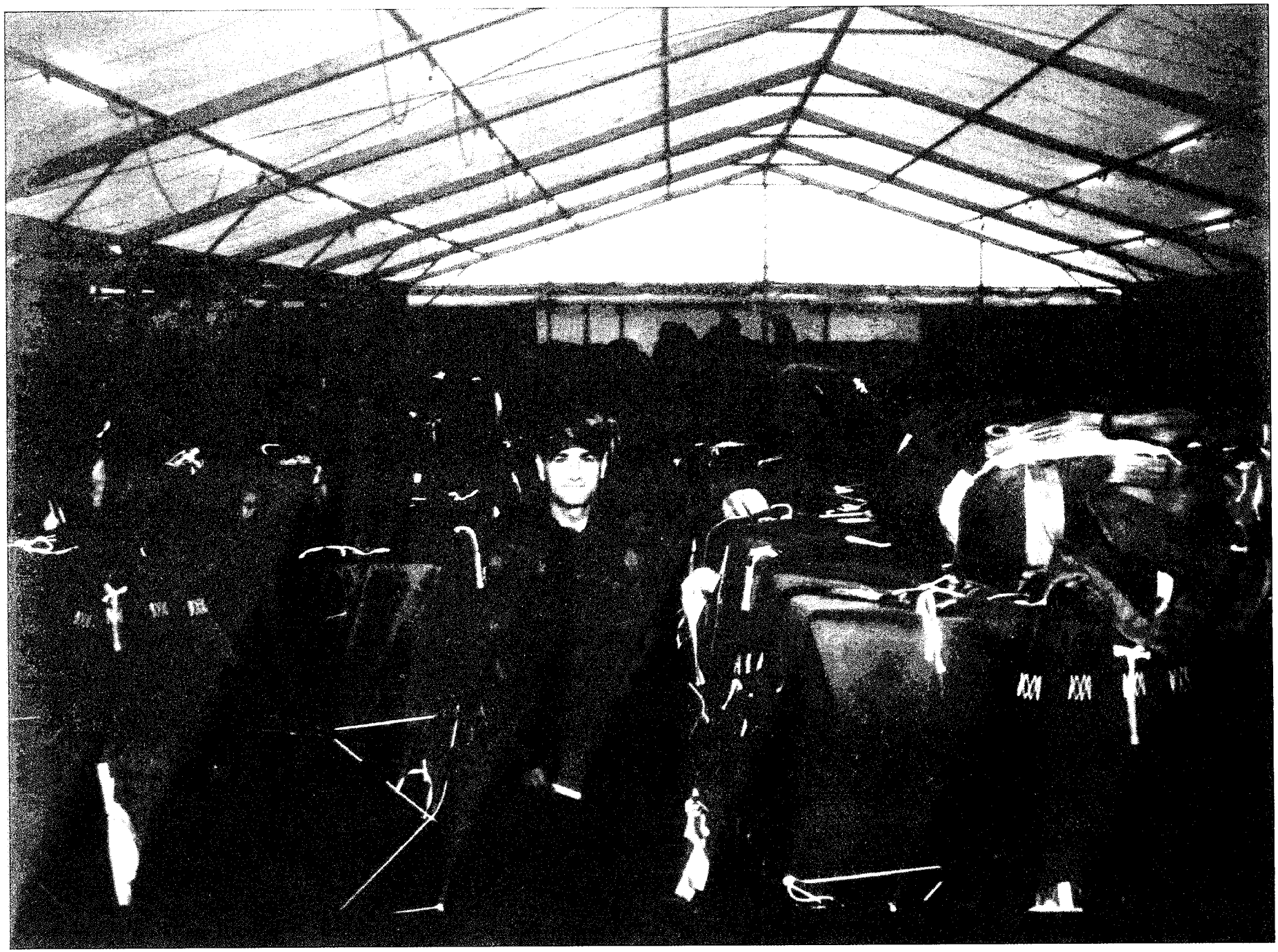
Flip chip technology has many advantages over other technologies including greater reliability and higher density electronic packaging. Flip chip technology will enhance the Air Force's ability to produce more reliable electronic devices and at the same time, reduce the size and weight of weapon systems components. The flip chip process results in an overall 30-50 percent reduction in cost due to the increased line yield.

Accomplishment

Under a program sponsored by the Manufacturing Technology Directorate, Hughes Microelectronics Division improved manufacturing processes for "bumping" technology used on flip chip gallium arsenide monolithic microwave integrated circuits (MMIC). Flip chip bumping process yields were increased 15-30 percent while manufacturing cycle time was reduced from 184 hours for upright wafers to around 117 hours for flip chip wafers during full production.

Background

There is a need to reduce the size and weight of electronic components in weapon systems. Flip chip technology, which can achieve higher density electronic packaging, is a cost-effective means to reach this goal while improving the system's reliability by eliminating wirebonds, which are fragile and easily broken. Key to the success of flip chip technology is controlling the size and width of "bump," which is a minute ridge on a gallium arsenide MMIC. Flip chip technology is so promising that the Directorate awarded two separate contracts to Hughes Microelectronics Division, Torrence CA. One project investigated ways to improve manufacturing processes of flip chip MMICs, especially the bump technology. The other project manufactured a flip chip high power amplifier. Improving the manufacturing process resulted in Hughes engineers achieving a state-of-the-art gallium arsenide bumping process for placing silver bumps 4 millimeters tall onto coplanar waveguide circuits with high visual and performance yields. Hughes took advantage of the new "bumping" technology and in the second effort produced a flip chip high power amplifier which is used on advanced phased array radar systems. Hughes engineers examined the baseline manufacturing process flow of high power amplifier MMICs to establish the critical statistical process control parameters. For each step, they defined electrical parameters affecting yield and were able to improve each process. This program yielded bumped MMIC devices that were used in the Air Force's transmit and receive module program. Hughes is also currently working on applying flip chip technology for Delco's Near Obstacle Detection System for automobiles.



Global Positioning System (GPS) Wind Measurements For "Operation Provide Promise"

Payoff

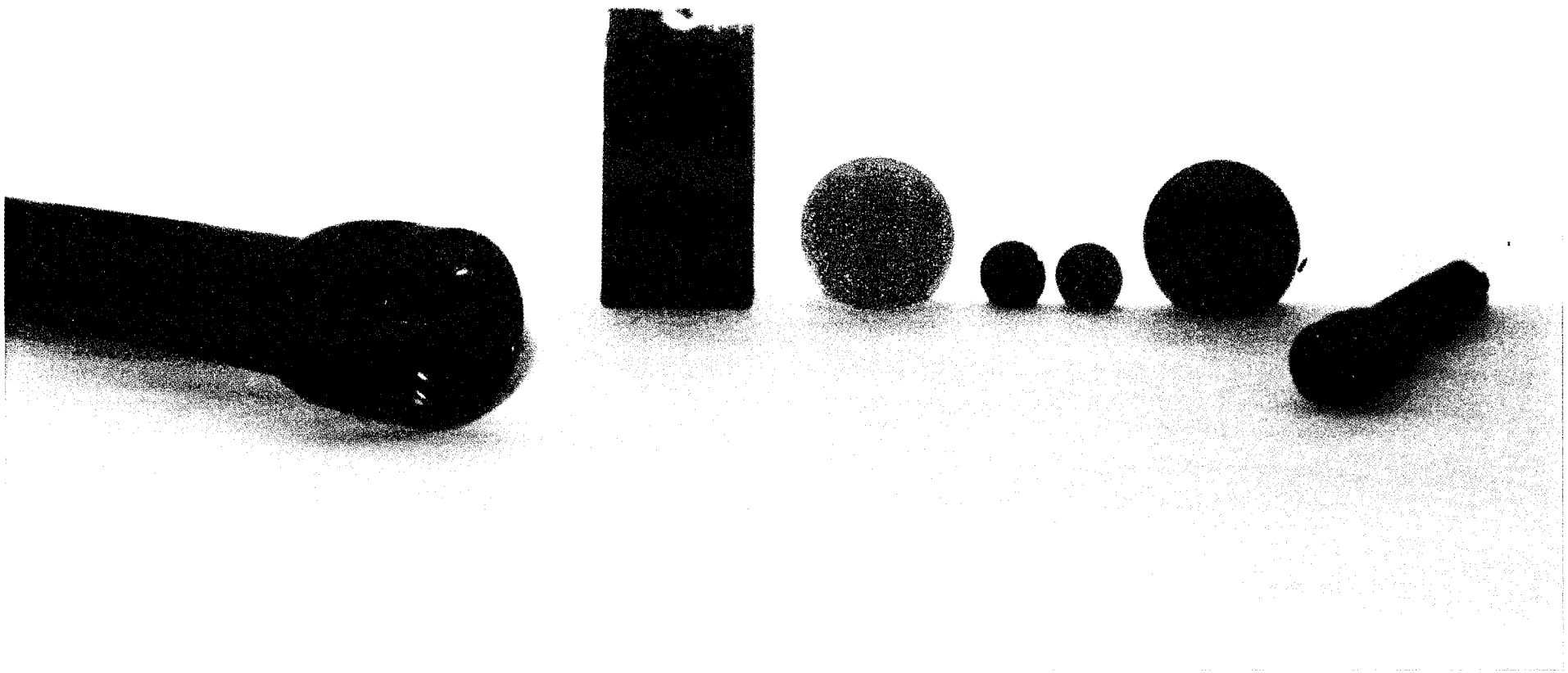
Actual wind measurements over Bosnian drop zones, in support of Operation Provide Promise, will improve high-altitude (over 15 kft) airdrop accuracy by more than 50%. By solving the mission critical need to improve the aerial delivery capability and effectiveness over Bosnia-Herzegovina, a technology will be transitioned to an Air Force fleet that addresses a current operational requirement.

Accomplishment

Through direct interactions with the 435th Operation Group, Rhein-Main Air Base , Germany, the Flight Dynamics Directorate created an alliance to develop a near-term solution to improve high-altitude airdrop accuracy for the delivery of food and supplies to Bosnian drop zones. To effect a solution, the Directorate and the U.S. Army Atmospheric Sciences Division (ASD) at White Sands Missile Range teamed to successfully test a GPS dropsonde (wind and meteorological sensor package) atmospheric measurement system for the airdrop application. In-flight wind data obtained at Yuma Proving Grounds, during a 28 July 1994 proof-of-concept test of a GPS dropsonde deployed from a C-130, revealed a wind speed maximum at 2000 ft that conventionally-obtained data from the base weather station smoothed out. This sort of low-level wind maximum cannot be forecasted nor picked up using conventional measurement techniques and can significantly degrade airdrop accuracy.

Background

The Directorate's Precision Airdrop Program Manager (PM) visited the 435th Operation Group to investigate all airdrop activities associated with Operation Provide Promise. During the in-brief, the Group Commander asked what Wright Laboratory could do for his operation (in the near-term) to measure upper-air winds over Bosnia. The Commander's navigators rely on 10-12 hour wind forecasts or percentages of flight-level winds to calculate the air release point for each drop. The Precision Airdrop PM made a commitment to investigate a potential solution to the ballistic winds problem. Although GPS technology has been on-the-shelf for quite some time, only one company has integrated the technology into a fully automated, upper-air sounding product. To provide more accurate and affordable range support, ASD developed and purchased helium balloon- and rocket-launched versions of the GPS dropsonde system that replaces a ground-based radar wind profiler. Besides loaning this system for airborne testing, ASD has provided technical support and training. The Directorate plans to modify a GPS dropsonde system for the airdrop application and take that system to Germany for further test and evaluation during actual airdrop missions over Bosnia.



Customized Optical Filter Supports Special Operations Squadrons

Payoff

The Materials Directorate's hands-on, real-time approach to developing a flashlight bulb and filter combination that does not saturate night vision goggles (NVGs) in the cockpit, has improved operational safety and performance for three Special Operations Squadrons and several Marine units at Hurlburt Field FL. Their analysis and solution saved the users the time and expense of a commercial development and procurement program.

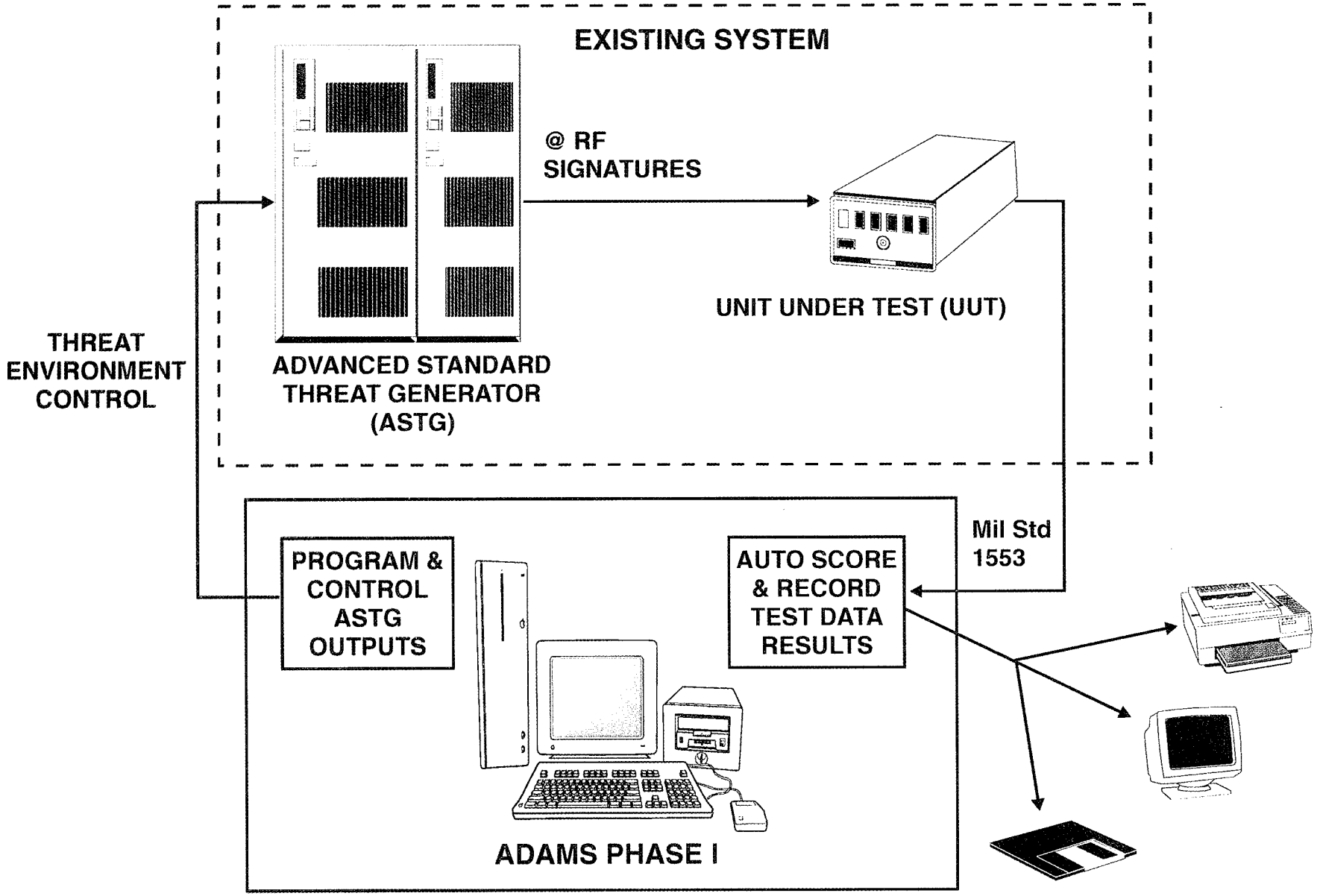
Accomplishment

Engineers at the Materials Directorate provided quick-reaction support to the 16th Special Operations Squadron (Gunship), the 20th Special Operations Squadron (PAVE LOW) and the 55th Special Operations Squadron (Blackhawk) at Hurlburt Field FL. They developed and fabricated a low-cost filter that allows aircrews to perform tasks in the cockpit under minimal lighting conditions during operations.

Background

During a trip to Hurlburt Field, engineers from the Materials Directorate's Electromagnetic Materials and Survivability Division learned of a problem that special operations aircrews were experiencing. Cockpit gauges and crew flashlights were saturating NVGs, limiting their use in the cockpit. A commercially available solution to the problem was unknown, and normal procurement methods to develop a special filter would take months and cost many thousands of dollars. The team brought the problem home, and quickly devised an in-house effort to solve the dilemma. Their challenge was to find a low-cost, off-the-shelf flashlight bulb and filter combination that would provide sufficient light in the visible spectrum, while allowing a carefully controlled amount of near infrared light for NVG illumination. Within two weeks, a team of Materials Directorate engineers had researched available materials, obtained, tested and characterized samples, and developed a filter that solved the compatibility problem. They then obtained a larger quantity of the necessary material and used their in-house 1 kilowatt laser to cut over 300 filters, which were delivered to units at Hurlburt within six weeks of problem identification.

WR-ALC ELECTRONIC WARFARE FACILITY



A Digital Avionics Methodology Schema (ADAMS) Prototype Transitioned

Payoff

A successful demonstration of the ADAMS prototype to Warner Robins Air Logistics Center (WR-ALC) engineers led to its transition to WR-ALC to be used in support of ALR-69 Class IV radar warning receiver block cycle tests. The computer-based system will replace a significant portion of the time and labor intensive resources applied when testing the Operational Flight Programs (OFPs) using realistic and dynamic radio frequency (RF) signals. In support of Special Operations Forces, a second copy of the prototype was acquired for use at WR-ALC.

Accomplishment

The Avionics Directorate, using a first-cut prototype, demonstrated a methodology to WR-ALC test engineers that performs more rigorous, realistic and timely testing of the OFP used within modern avionics equipment. This low-cost, non-intrusive, Automatic Score and Report computer-based system will reduce the resources needed to generate, collect, score and evaluate the complex data generated during an OFP's verification and validation testing cycle. ADAMS concept will be matured and continued in further phases.

Background

The ADAMS project was initiated in 1993. In cooperation with WR-ALC, where OFP testing is extensively performed, the ALR-69 Mod IV radar warning receiver and the WR-ALC Advanced Standard Threat Generator RF laboratory testbed were selected to prove the ADAMS concept. The first project milestone was to demonstrate, using a working prototype, that the RF testbed controlling function was technically and economically feasible. Employing a standard 486 DX personal computer with contractor developed hardware cards and software, the demonstration was held at WR-ALC on 16 Nov 93.

The first-cut prototype test established: (1) feasibility of auto-scoring and auto-control of the RF testbed and stimuli; (2) effective duplication of some of the manually intensive test subprocesses; (3) potential savings in block cycle schedule time by utilizing a simulator under automated control; and, (4) increased productivity due to controlled subprocesses. ADAMS was determined to be compatible with the structured and disciplined PREDICT-TEST-ANALYZE-COMPARE test process.

Auto-Inspect System Reduces Time and Increases Efficiency for Aircraft Component Inspections

Payoff

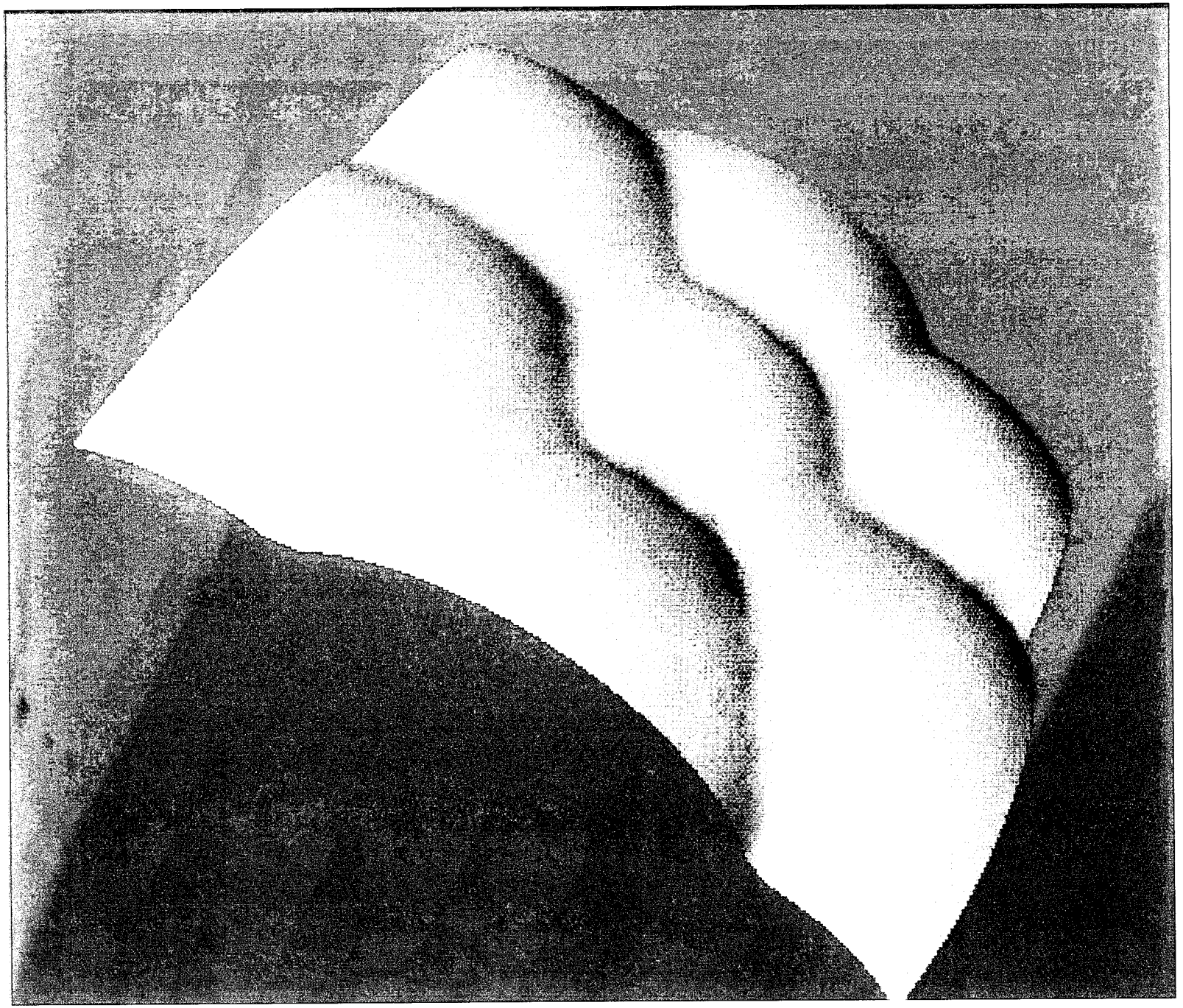
The generation of scan-plans (machine codes that run the Retirement For Cause (RFC) equipment for an aircraft component) by the AUTO-INSPECT software system will reduce the time required to create inspection scan-plans for the F100-PW-229 engine from three years to 15 weeks. For most aircraft components, the time required for creating a scan-plan will be reduced from months to days and the efficiency will be increased such that the Air Logistics Centers (ALCs) will be able to create and maintain their own scan-plans.

Accomplishment

The Materials Directorate developed and successfully demonstrated a system for automatically generating scan-plans necessary for aircraft component inspections. The Directorate has established a Cooperative Research and Development Agreement (CRDA) with Systems Research Laboratory (SRL) of Dayton OH to apply this automatic scan-plan generation system to the RFC program for the F100-PW-229 engine.

Background

Scan-plans are machine codes that run the RFC equipment. They enable automated material degradation inspections of parts based on their known physical geometry. They have been historically difficult for the ALCs to create and maintain, requiring the use of a contractor to perform labor intensive measurements and translation into a computer code to execute the inspection by RFC robotically controlled equipment. The success of the RFC program has allowed aircraft components to be inspected for material flaws rather than just be thrown away. Engineers in the Materials Process Design Branch of the Materials Directorate, aware that the ALCs have long been searching for a way to reduce the effort required to create and update scan-plans for part inspections, developed an automatic scan-plan generation system called AUTO-INSPECT (patent pending). This computer software system incorporates an expert system, process planner and a computer-aided design (CAD) system to translate the geometry of the CAD solid body drawing into a scan-plan that can be used to perform inspections of the part. Under a CRDA between the Materials Process Design Branch and SRL, the automatic scan-plan generation system will be applied to the RFC program for the F100-PW-229 engine. The current manual inspection scan-plan generation technique for this engine averages about two and one-half months per part. Since the PW-229 engine has 15 parts consisting of disks, shafts, seals, spools and combustion cases currently in the RFC program, the manual creation of scan-plans for this engine would take almost three years. Utilization of the automated scan-plan generator will reduce the two and one-half month preparation time per part to one week. The scan-plan generator will also allow for easier modification of existing scan-plans as new probes and scanning technologies are introduced. The successful demonstration of the scan-plan generator included an inspection of the Stage 1 turbine air seal of the F100-PW-229 engine. The F118-GE-100 (for the B-2) engine ALC (Tinker AFB) asked that the system be applied in its engine maintenance contracts.



DSD Calculated Detonation Wave

Detonation Shock Dynamics Computer Code Helps Weapon Analysts

Payoff

Using the Detonation Shock Dynamics (DSD) computer code to achieve faster and more accurate calculations on detonation waves in a warhead will result in cost savings in the overall weapon design process. The computer code has application beyond the weapon community, i.e., predicting the performance of explosives used for mining, and will be incorporated into the Air Force's standard Elastic Plastic Impact Code.

Accomplishment

Under a program sponsored by the Armament Directorate, a mathematical breakthrough has been achieved that will enable weapon designers to use computers to accurately track the position of detonation waves in warheads. A computer code based on a theory called DSD has simplified a complex, time-consuming process previously used to calculate the detonation process.

Background

Although scientists understand how explosives work, they have been unable to accurately calculate the detonation wave position in a weapon due to the time-consuming calculations that were required to model real events on today's super computers. As a result, explosive theory was ignored and Huygen's construction, a method that allows the detonation wave position to go in all directions at its detonation velocity, has been employed. Computational results obtained with this method are compared to actual tests, errors are identified, and the computer run is repeated with a fix incorporated to correct timing errors. Now, thanks to the breakthrough in detonation theory, weapon analysts can achieve faster and more accurate calculations on a detonation wave than can be obtained with the corrected Huygen's construction and computer rerun. Funded by Wright Laboratory's Armament Directorate, researchers at the University of Illinois, Urbana-Champaigne, developed a computer code based on the theory of DSD that accurately tracks detonation waves. According to this theory, detonation velocity is a function of the wave curvature. If the wave is curved and expanding, it slows down. But, if it is curved and contracting, it speeds up. Although is sounds very simple, it has a profound effect on the equations used to model explosives, and it is physically realistic. The computer calculation naturally follows the wave's progress, and can even accurately model two impacting waves.

Materials Directorate and Sacramento-Air Logistics Center (SM-ALC) Team Receives Award

Payoff

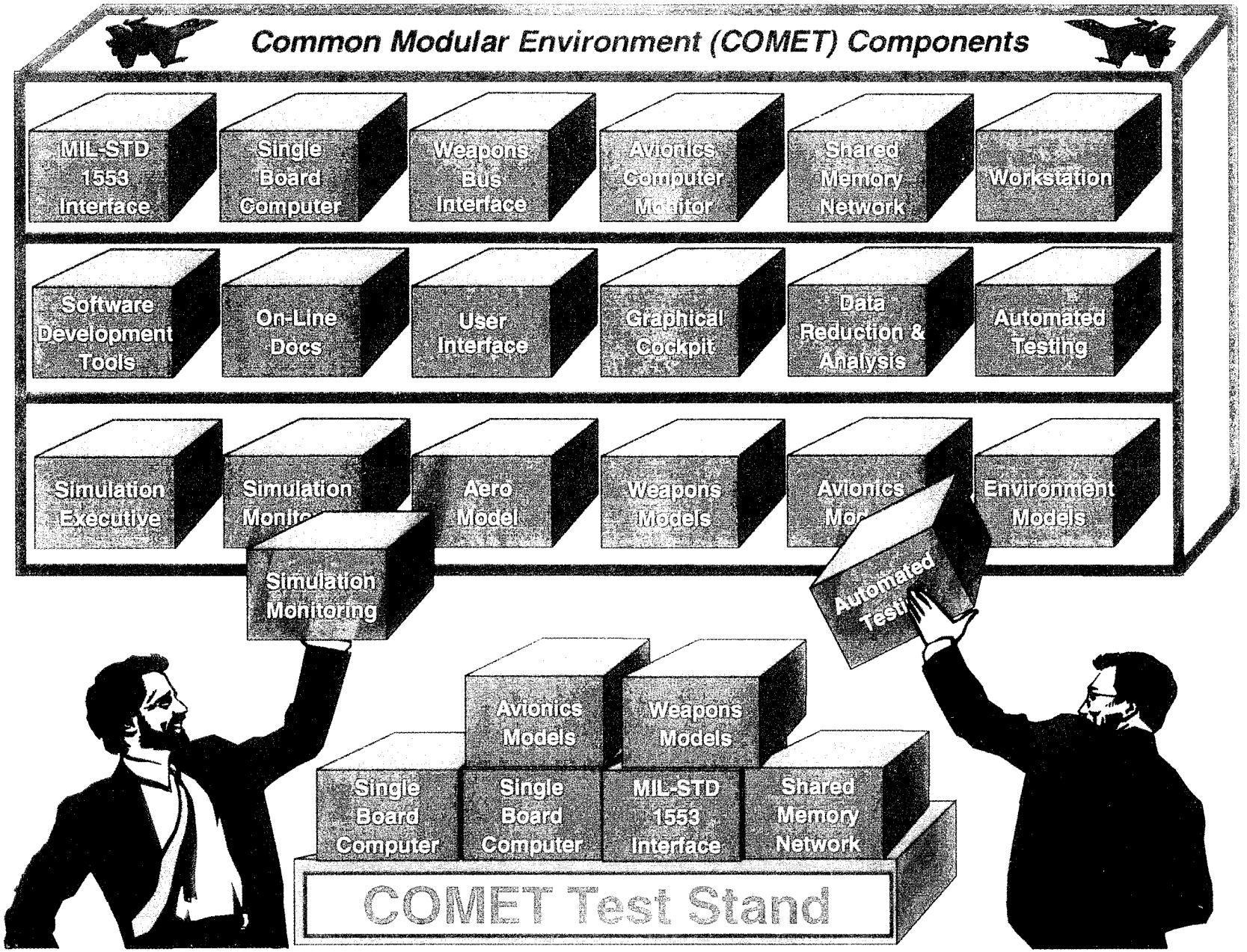
A joint Wright Laboratory Materials Directorate and SM-ALC engineering team was presented the first Lieutenant General Thomas R. Ferguson, Jr. award by General Ronald Yates, Commander Air Force Materiel Command, for technology transition from the laboratory to an operational system. The team won the award for their work in solving a heat damage problem on the F-117A stealth fighter.

Accomplishment

The team of engineers from the Materials Directorate and SM-ALC received the Lieutenant General Thomas R. Ferguson, Jr. Award for Excellence in Technology Transition. Mr. Kenneth M. Johnson, Dr. James R. McCoy and Captain Michael W. Holl from the Materials Directorate and Messrs. Allegra D. Hakim, Richard B. Warnock, Anthony Brindisi and Dennis M. Conboy from SM-ALC were recognized for their contributions to the development and transition of a new, high-temperature advanced composite material to the F-117A stealth fighter.

Background

The Lieutenant General Thomas R. Ferguson, Jr. Award for Excellence in Technology Transition was established to honor the General's contributions to the Air Force Science and Technology Program. At the time of his retirement in 1993, Lieutenant General Ferguson was commander of the Aeronautical Systems Center, Wright-Patterson AFB OH. The award will be presented annually to the individual or team responsible for the most significant transition of technology from the laboratory to an operational Air Force system during the previous year. The first award was presented to a team of Materials Directorate and SM-ALC engineers for their efforts in transitioning a new, high-temperature composite material, called AFR 700B, that solved a recurring heat damage problem on the fuselage trailing edges of the F-117A stealth fighter. The Directorate's Nonmetallic Materials Division, working jointly with the F-117 System Program Office (SPO) at SM-ALC and the USAF Advanced Composites Program Office, initiated efforts to replace the current trailing edge composite material parts with AFR700B parts to correct the problem. Following a successful flight test, the F-117A SPO accepted them for use on all F-117A aircraft. SM-ALC determined they could fabricate the parts in-house at a cost $5 million below the price estimated by an outside vendor. SM-ALC is collecting data to determine life cycle cost savings by using the AFR700B trailing edge parts.


Common Modular Environment (COMET) Components
MIL-STD 1553 Interface
Single Board Computer
Weapons Bus Interface
Avionics Computer Monitor
Shared Memory Network
Workstation
Software Development Tools
On-Line Docs
User Interface
Graphical Cockpit
Data Reduction & Analysis
Automated Testing
Simulation Executive
Simulation Monitor
Aero Model
Weapons Models
Avionics Mo
Environment Models
Simulation Monitoring
Automated Testi
Avionics Models
Weapons Models
Single Board Computer
Single Board Computer
MIL-STD 1553 Interface
Shared Memory Network
COMET Test Stand

Simulation Technology Improves Post Deployment Software Support For F-16C/D

Payoff

A new generation of avionics software support equipment, developed in-house by Wright Laboratory's Avionics Directorate, has been transitioned for use at Ogden Air Logistics Center (OO-ALC) for use in post deployment software support of the F-16C/D avionics. Through a highly modular design, a series of common "building blocks" can combine to produce multiple avionics software test stations. The result is increased productivity/flexibility and reduced maintenance costs. The approach has saved the F-16 System Program Office (SPO) an estimated $22.4 million in initial development costs. Greater savings are expected with future upgrades and maintenance.

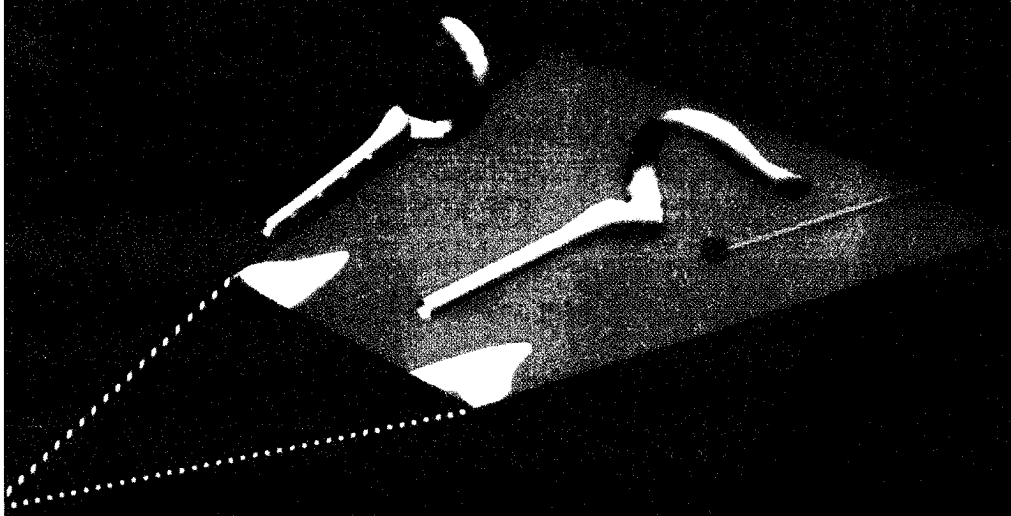
Accomplishment

In-house research, in the Avionics Directorate's System Avionics Division, has led to the development of a new post deployment software support capability for the F-16C/D aircraft, called the F-16 Common Modular Environment (COMET). The COMET will contain a complete software development environment, along with numerous test stations to debug and validate the complex avionics software.

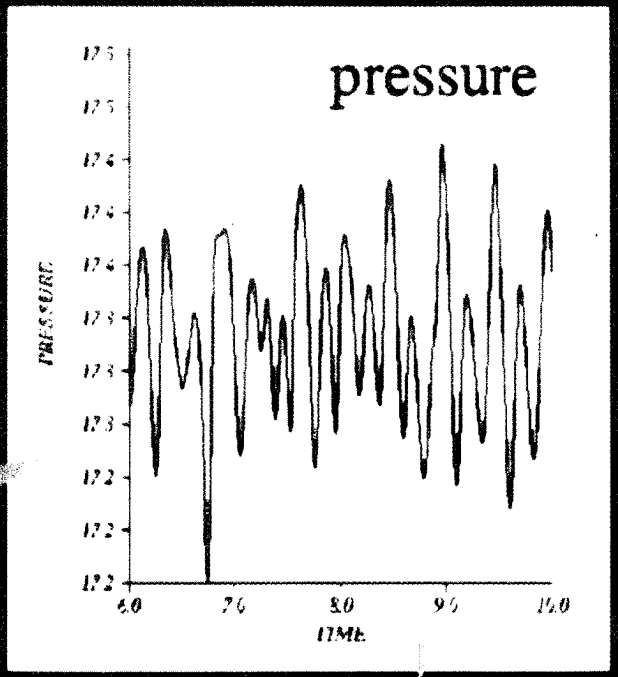
Background

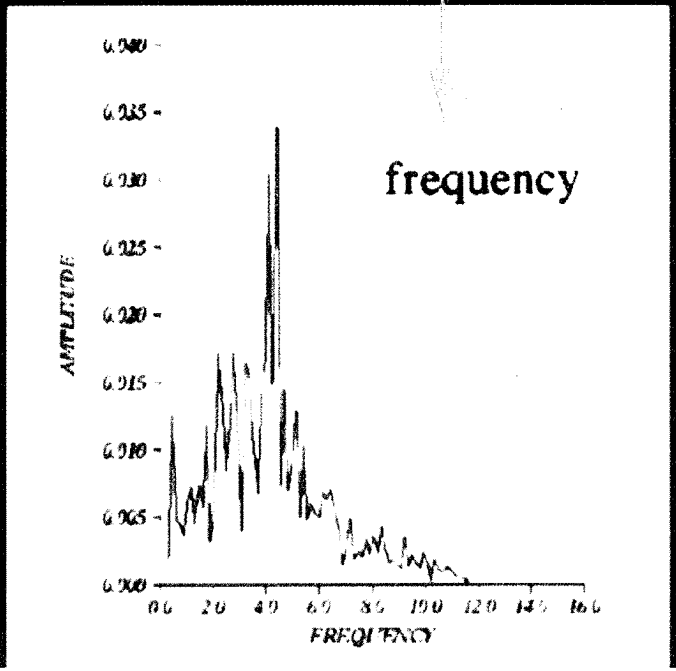
In 1989, the F-16 SPO began the process of procuring a post deployment software support capability for the main F-16C/D computers. The planned procurement included the purchase of several test stations from General Dynamics (now Lockheed Fort Worth) at a cost of over $65 million. Since OO-ALC is responsible for post deployment software support for the F-16, the software development tools and test stations were to be delivered and installed at Hill Air Force Base UT. At an F-16 Computer Resources Working Group (CRWG) meeting, the Ogden engineers briefed the F-16 SPO and Avionics Directorate engineers on their expected workload. Their workload was driven by Air Combat Command (ACC) requirements for updates and enhancements to the F-16C/D embedded computer software. During the briefing, OO-ALC demonstrated that the planned test station purchases could not satisfy ACC requirements. Several other test stations would have to be purchased with an expected cost of over $100 million. Following the meeting, Wright Laboratory's engineers developed a proposal for a new approach to the development of a post deployment software support capability for the F-16C/D that employed in-house developed technologies and methods, and an object oriented design that allows a series of common components to be configured into various test stations. Through modularity and reuse, a large number of test stations could be produced and maintained much more cost effectively than traditional approaches. The test stations developed by Wright Laboratory are also more versatile and capable. Both the F-16 SPO and OO-ALC approved the proposal, and the technology is being utilized in support of the F-16 C/D avionics.

Unsteady Vortex Breakdown Above Stationary Delta Wing



angle of attack = 34 deg.





COMPUTER SIMULATION OF VORTEX BREAKDOWN

Payoff

The capability to accurately simulate the phenomenon of vortex breakdown above an aircraft wing using computational fluid dynamics (CFD) provides a cost-effective means of investigating methods for vortex breakdown control. Effective vortex breakdown control will reduce tail buffet and increase the service life of high performance aircraft.

Accomplishment

Wright Laboratory researchers achieved, for the first time, an accurate numerical simulation of the onset of vortex breakdown above a maneuvering delta wing. Using a CFD code developed in-house, engineers from the Flight Dynamics Directorate's Aeromechanics Division fully validated their computational results by detailed comparison with one-of-a-kind experimental experiments.

Background

Vortices above fighter aircraft at high angle of attack experience a dramatic form of flow disruption known as vortex breakdown. This phenomenon is characterized by internal stagnation of the flow and by swelling of the vortex core, and is accompanied by marked flow fluctuations. Vortex breakdown poses severe limitations on the performance of agile aircraft due to its sudden drastic effects on the aerodynamic forces and moments, and their impact on aircraft stability and control. Additionally, the strong fluctuations within the vortex core can induce pronounced structural oscillations of an aircraft wing or tail, with dynamic loads over one hundred times those experienced in normal flight. This is the case of "tail buffet" in twin-tailed fighter aircraft where the fluid/structure interaction may result in significant reduction of the service life of structural components. The need to accurately simulate this flow phenomenon using CFD became apparent in recent years. To accomplish this task, the Aeromechanics Division developed an efficient time-accurate numerical flow solver and validated this productive tool for various vortical flows on aircraft components.

Expert System Reduces Cost of Tool Design in Fabrication of Composite Structures

Payoff

The artificial intelligence expert system called Advanced Tooling Manufacture for Composite Structures (ATMCS) has automated the tool design functions used in the manufacture of composite structures. This knowledge-based system reduces tool design time by up to 98 percent and overall tooling costs by 25-45 percent. It will be made commercially available through a Cooperative Research and Development Agreement with Stone and Webster, Boston MA.

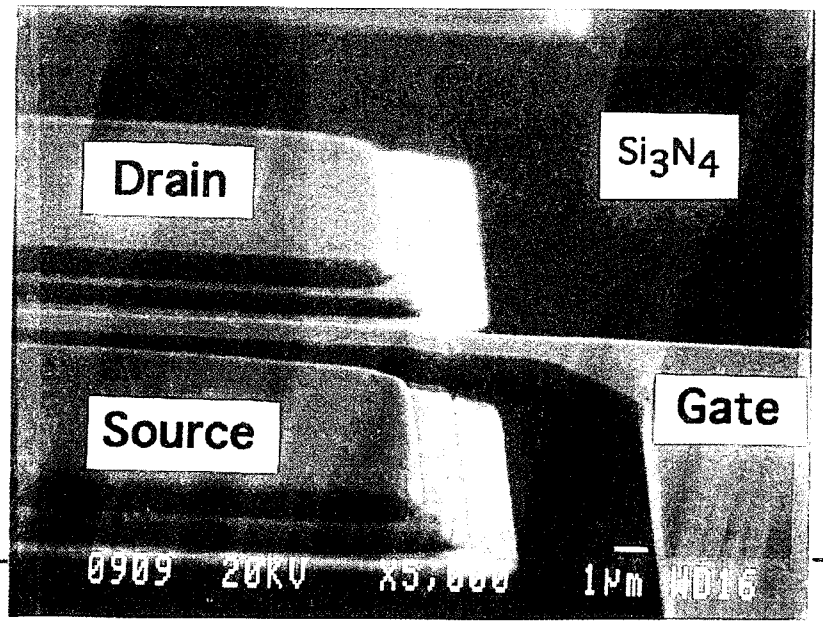
Accomplishment

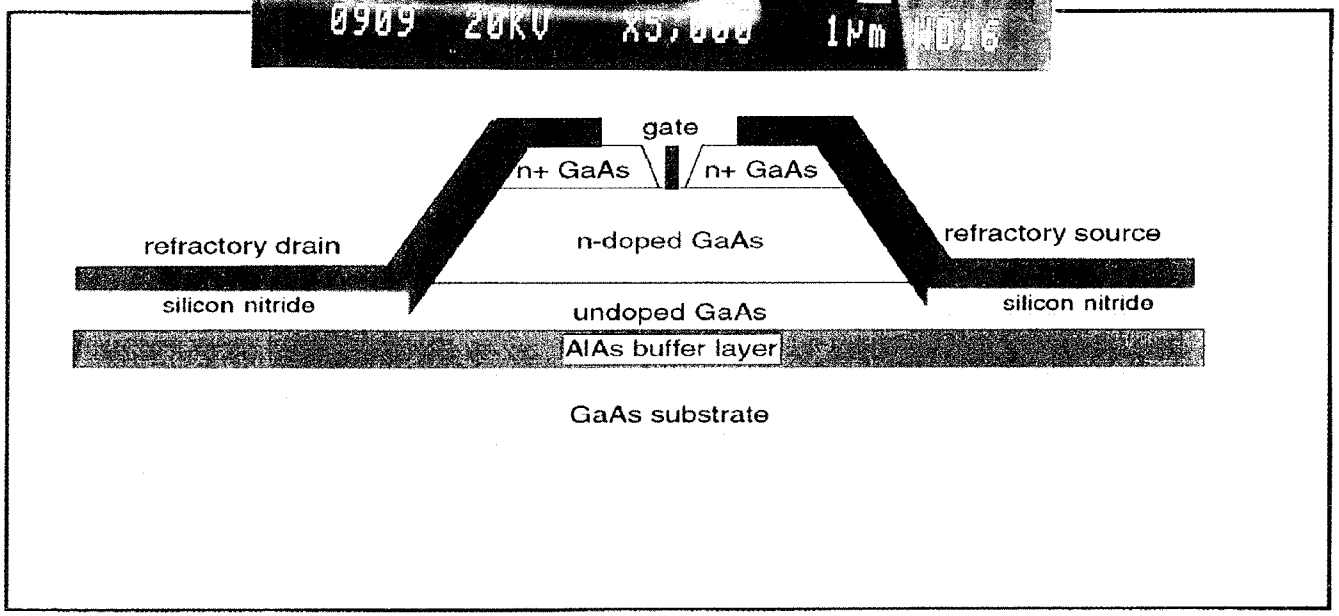
Researchers under a program sponsored by the Manufacturing Technology Directorate demonstrated an integrated methodology for automating the tool design functions for the manufacture of tooling used in the fabrication of composite structures. Tasks which used to take hours now only take minutes.

Background

Advancements in materials and manufacturing have provided advanced composite materials with proven engineering and performance that are being used extensively in Air Force weapon systems. However, tooling technology has not advanced as rapidly as the development of automated, labor saving, material placement techniques and design technology. With the introduction of complex shaped parts and higher temperature composite materials, the need for tools compatible with the composite fabrication process has become essential. The expanded application of composites into more of the airframe structure introduced important production factors such as tool fabrication lead times, life, part reproducibility and integrity. All are important considerations to overall manufacturing costs. In many cases, these factors are done on a trial-and-error basis for each composite part with substantially different configurations. The Manufacturing Technology Directorate awarded a contract to Northrop to establish an artificial intelligence expert system which will provide information on tooling materials and fabrication techniques for optimum production tooling. The ATMCS system consists of a knowledge base of tooling rules, and can be accessed by users using already established computer-aided design hardware and software interfaces. Use of the ATMCS system to design a composite tool resulted in dramatic decreases in tool design time. The ATMCS is currently being used by UCAR Components Incorporated, Dow Technologies, Northrop, and Rohr Industries.

Photomicrograph and Schematic of Wright Lab MESFET





Operability of Gallium Arsenide Metal Semiconductor Field Effect Transistor (GaAs MESFET) Devices Enhanced

Payoff

Reliable semiconductor operation at temperatures above the current military requirement of 125°C will enable GaAs MESFET devices to operate in remote locations of a high-performance aircraft, where active cooling is inadequate. By increasing GaAs MESFET reliability at elevated temperatures, the size, weight, and power consumption demands placed upon the aircraft's environmental control system will be reduced.

Accomplishment

The Solid State Electronics Directorate's Research Division applied bandgap engineering principles to develop a semiconductor fabrication process which enables GaAs MESFETs to operate reliably at temperatures up to 350°C ambient. This innovation enhances the operability of MESFET devices in a circuit at elevated temperatures without increasing the processing complexity and can improve the lifetime of the device at conventional ambient temperatures by a factor of 700.

Background

There is a need for high temperature robust solid state microwave devices. In aircraft, over 50% of all electronic failures are directly attributed to high temperatures and inadequate cooling. More than 90% of the capacity of the aircraft environmental control system is currently used to cool electronics. Future high performance, advanced avionics will be limited by these thermal issues. One of the device failure mechanisms at elevated temperatures is due to metal contact degradation. Another problem at elevated temperatures is that semiconductors become more conductive, and the resulting leakage current decreases the transistor's effectiveness in switching. In previous embodiments, the GaAs MESFET, the workhorse of the solid state microwave technology, experienced extensive performance and lifetime degradation when operating in temperature environments exceeding 125°C. The technology developed in-house by the Research Division overcomes these limitations. Specifically, this technology incorporates a high resistivity aluminum arsenide (AlAs) buffer layer beneath the GaAs MESFET channel to reduce the internal high temperature leakage current by more than an order of magnitude, and eliminates device-to-device leakage currents by placing the metal pads on silicon nitride, rather than on the semiconductor. Also incorporated is a nickel-germanium-indium-tungsten electrical contact layer which eliminates the need for rapid-diffusing metals such as gold in the metalization scheme. Devices made by this process operated reliably at 350°C ambient temperature, and have withstood periods of several hundred hours at 400°C without suffering performance-degrading diffusion of the contact metals into the semiconductor.


PERFECT

Peroxide in Fuel Estimation and Concentration Test (PERFECT)

Payoff

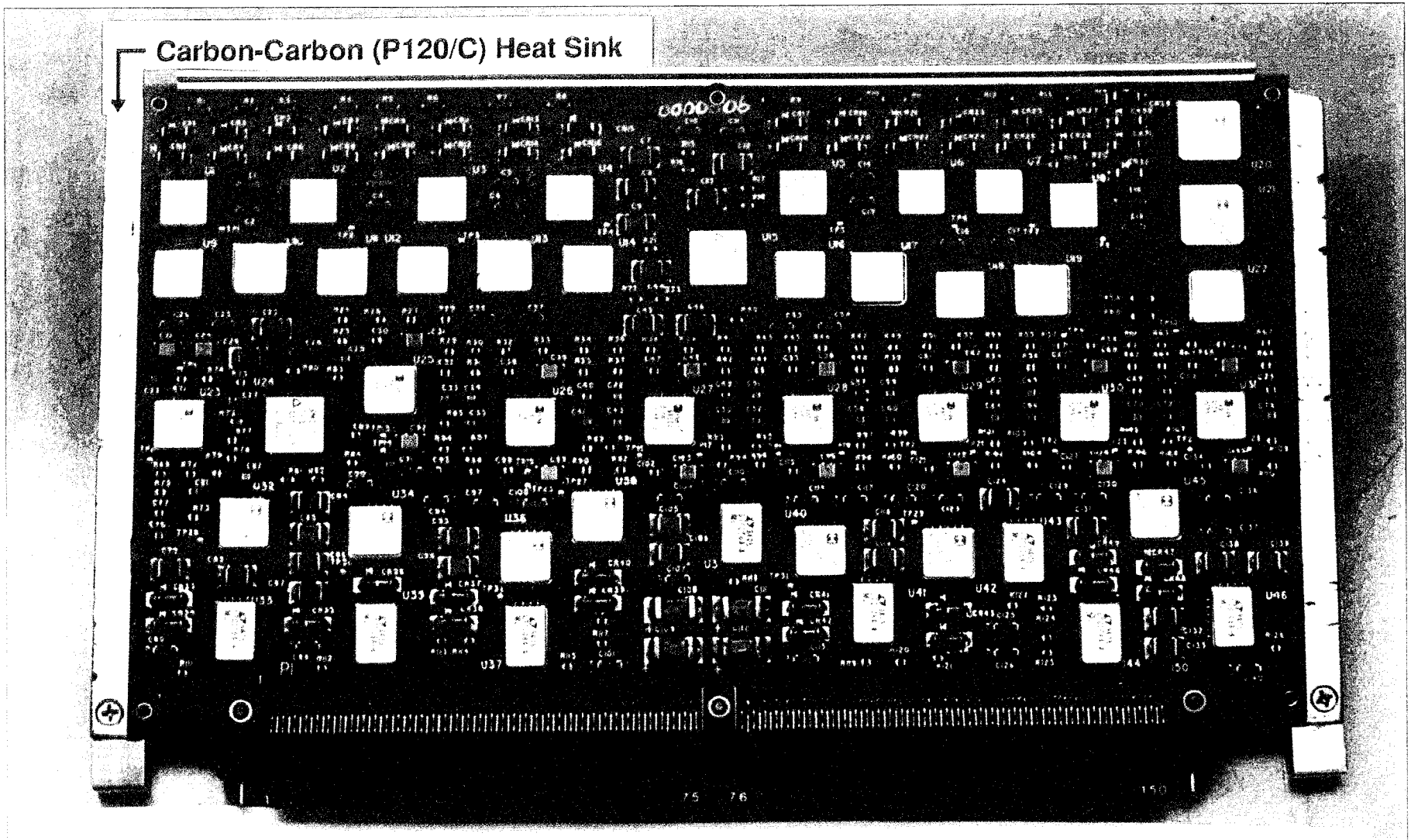
The new Ozone Depleting Chemical (ODC)-free PERFECT method will replace current test methods used by both military and commercial agencies for aviation and diesel fuel qualification and potentially by the food industry to determine the useful life of cooking oil. When low sulfur diesel fuels are required throughout the United States, it is envisioned that the test method will be instrumental in ensuring the quality of diesel fuels.

Accomplishment

The Aero Propulsion and Power Directorate successfully demonstrated a new efficient, environmentally friendly test method to determine the peroxide content of aviation fuels. This PERFECT method reduces sample size by 90%, reduces laboratory waste by 95% and can analyze samples twelve times faster than the conventional method.

Background

The Clean Air Act requires the removal of ODCs from military and commercial specifications. The Directorate's Fuels Branch has been working with the American Society for Testing and Materials (ASTM) to eliminate ODCs from standard test methods used to qualify aviation fuels such as ASTM D 3703, Standard Test Method for Peroxide Number of Aviation Turbine Fuels. This test method requires the use of Freon 113, a known ODC. The determination of peroxide number is very important for aviation fuel, especially fuel that has been in storage for more than six months. The PERFECT unit, developed by the University of Dayton Research Institute under the Directorate's sponsorship, is a test for jet fuels that is similar to ASTM D 3703, but does not require the use of ODCs. A bench-top unit is available for laboratory use and a portable hand-held unit is available for field use. A team of Air Force, Army, Navy, Defense Fuel Supply Center and industry personnel was established to expedite development of the PERFECT method to be used in both military and commercial aviation jet fuel specifications. In June 1994, the Directorate managed a round robin test program that included ten different military and commercial laboratories testing both diesel and aviation fuel samples. The purpose of this test program was to prove the technology of the test method and provide ASTM with the data required to convert it into an ASTM standard test method.



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Carbon-Carbon Materials for Electronics Packaging will Double Reliability, Save Millions

Payoff

The use of carbon-carbon materials for heat sinks offers an advanced lightweight solution for electronic packaging problems. These materials will increase the reliability and life span (150-200 percent increase) of electronic devices while reducing their weight and temperature rises. The increased reliability factor obtained by using carbon-carbon heat sinks for spacecraft, aircraft and missiles will save millions of dollars in life cycle costs.

Accomplishment

Under a Small Business Innovation Research (SBIR) program sponsored by the Materials Directorate, the feasibility of using carbon-carbon composite materials to improve heat control in electronic devices was demonstrated. Applied Materials Technologies Inc., Santa Ana CA, found that using carbon-carbon composite material in place of aluminum for heat sinks reduces heat buildup in electronic circuit boards by 20 to 50 percent.

Background

Air Force aircraft, missiles and radar systems have very sophisticated mechanical, electrical and optical components that require high density electronics to provide reliable data processing. The increased sophistication of data processors requires effective electronic packaging schemes to ensure reliable temperature regulation of printed wiring board components. The current preferred industry electronic packaging approach mounts high density printed wiring boards in a back-to-back configuration separated by an aluminum thermal heat sink. Aluminum, however, does not have adequate thermal conductivity to achieve high density electronic packaging. As the density of electronic packaging (i.e., the quantity of integrated circuits placed on a printed wiring board) increases, the ability of conventional metal materials to effectively dissipate heat is limited. To overcome these limitations, packaging engineers increase the thickness of heat sinks or provide a fan to transport heat away from electronic components. Both of these solutions add weight to electronic devices. Fans also add a higher degree of complexity to the system and are not an option for use in spacecraft. Applied Material Technologies Inc. not only demonstrated that using carbon-carbon material for heat sinks reduces the temperature rise of the heat source by up to 50 percent over aluminum heat sinks, but also found that carbon-carbon heat sinks are 30 percent lighter and three times stiffer than aluminum heat sinks, which are both critical design parameters. Under an SBIR Phase II project, Applied Material Technologies Inc. will develop and flight qualify a carbon-carbon heat sink product for electronic packaging. The results of the Phase II project could provide a means of increasing the density of circuits on printed wiring boards well beyond what is currently achievable.

Federal Lab Consortium Award for Excellence in Technology Transfer

Payoff

In recognition of the transfer of Aero Propulsion and Power Directorate's engine vibration and diagnostic technology to a commercial application, a team led by Dr. William A. Troha was presented a 1994 Federal Laboratory Consortium Award for excellence in Technology Transfer. The cost savings to both commercial airlines and the military, resulting from reduced engine removals from on-the-wing operation and inherent test cell running, has given the portable gas turbine vibration diagnostic and balancing production unit, identified as PBS 4100, a competitive position in the international market.

Accomplishment

Dr. William A. Troha of the Aero Propulsion and Power Directorate and Messrs Rick Rio and Dave Kennison from Mechanical Technology Inc. (MTI), Latham NY, were recipients of a 1994 Federal Laboratory Consortium Award for Excellence in Technology Transfer for their dedication and perseverance in the transfer of gas turbine vibration diagnostic and balancing technology into a portable, world-class production unit competitively sold internationally. The consortium's annual award for excellence in technology transfer is given to a select number of individuals who demonstrate their commitment by actively working to transfer a technology or process to the public or private sector.

Background

The engine vibration and diagnostic technology developed by Dr. Troha was initially identified as the Automatic Vibration and Diagnostic (AVID) system and was introduced into test cells nine years ago at Oklahoma City and San Antonio Air Logistic Centers (roughly two 6-foot high electronic racks--too large for portable application). They are still in use today. A portable prototype unit was released in 1988, which coupled the AVID system with capabilities of advanced personal computers. In the early 1990's, MTI introduced an upgraded Portable Balancing System, based on AVID system technology, identified as the PBS 4100. In addition to a balancing capability, the PBS 4100 incorporates a full range of diagnostic capability to identify engine vibration problems resulting in reduced maintenance time and effort. Before the development of this technology, a typical engine going through check-out after being overhauled would require an average of 4 run-times before meeting vibration limit tolerances. With the demonstration of the technology, this process was reduced to one engine run-time, resulting in a cost reduction of a factor of 4. The development of the commercial PBS 4100 system by MTI has established a new industrial standard and is providing significant cost savings to both commercial and military users. Airlines have reported cost savings associated with improved on-the-wing engine maintenance, aircraft not being removed from scheduled flights, reductions in engine run-time and fuel consumed and the number of engines not being shipped to a main base for balancing.


NASTRAN
Douglas Michel Nastran
Achievement Award
Victoria A. Tischler
For
Outstanding Contributions

Award for NASA Structural Analysis (NASTRAN) Contributions

Payoff

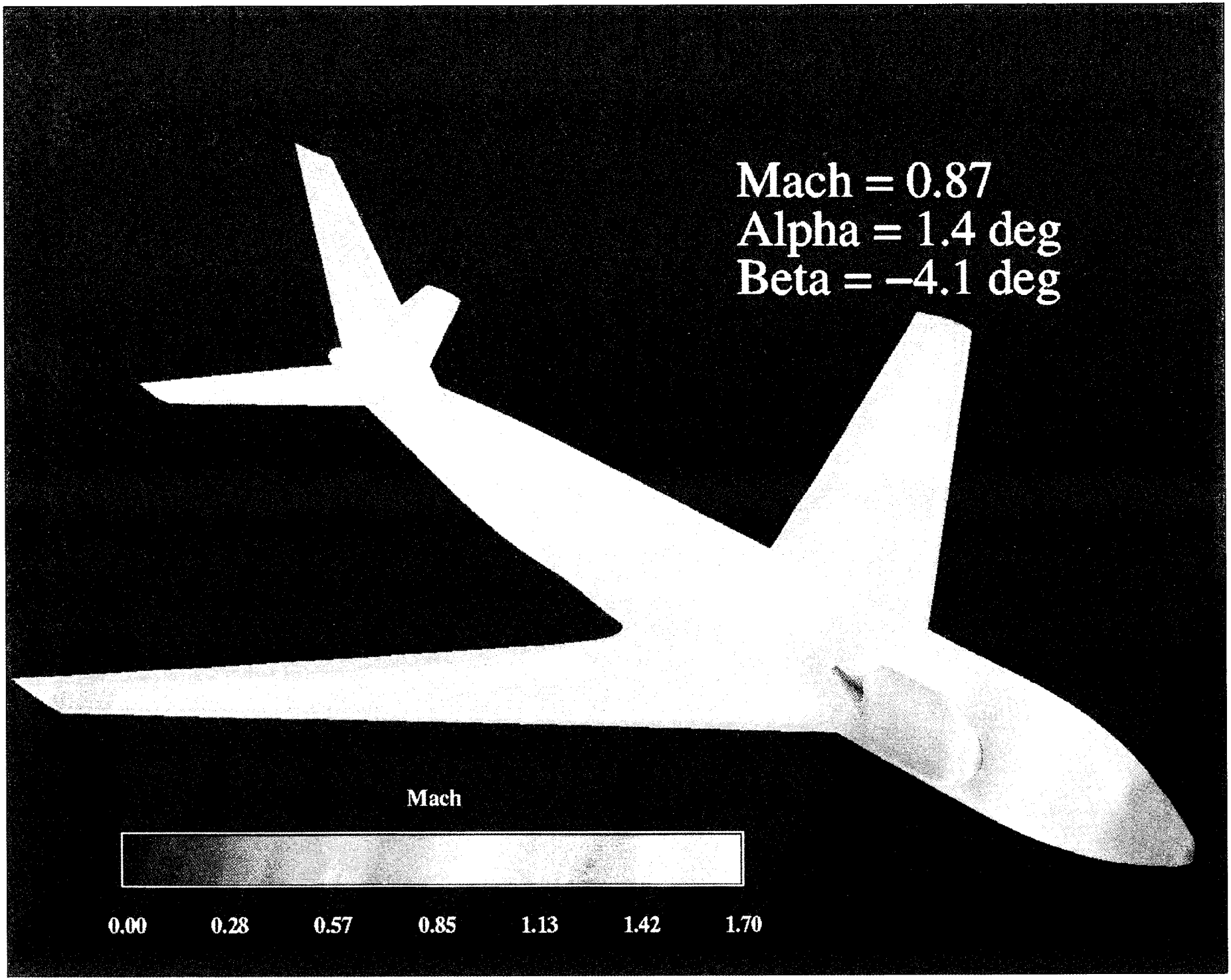
The contributions of Ms. Victoria A. Tischler have improved structural analysis methods which are essential for the production of optimum structural designs using new materials and structural concepts for advanced flight vehicles. She is a role model in showcasing Wright Laboratory's research and development achievements.

Accomplishment

Ms. Victoria A. Tischler of the Flight Dynamics Directorate's Structures Division received the 1994 Douglas Michael NASTRAN Achievement Award for lifetime contributions to NASTRAN development, usage and training. She performed development and verification studies on many key NASTRAN enhancements, including the QUAD4 plate binding element, unsteady aerodynamics and high performance eigenvalue analysis routines.

Background

The NASTRAN computer program is the most widely used general purpose structural analysis program in the world. Even though it was originally intended for structural analysis problems, its current applications include aeroelasticity, heat transfer, fluid structure interaction, acoustics, electromagnetics and many other applications. The QUAD4 is the most important element of NASTRAN when modeling the complex behavior of structures in both statics and dynamics problems. This element was not available in the Government version of NASTRAN until it was provided under a program sponsored by the Flight Dynamics Directorate. Ms. Tischler played a key role in this activity by performing development and verification studies on many key technology advancements made by the contractor to the element. Ms. Tischler was instrumental in formulating and testing innovative workshop problems for a training course that used NASTRAN to analyze complex flight vehicle structures. As a focal point and consultant for NASTRAN applications at Wright-Patterson Air Force Base OH, she conducted structural analysis on the F-16 wing carry-through structure, provided major support to the Federal Aviation Administration fuselage hardening program, worked to develop a finite element for viscoelastic material under high temperature and solved load and stress problems encountered in the wing load attachment lugs on the Air Force's T-1 trainer.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COMPUTATIONAL FLUID DYNAMICS (CFD) ANALYSIS SUPPORT

Payoff

The determination by the Flight Dynamics Directorate that a large splitter plate mounted on the side of a C-135 aircraft would provide a favorable flow field environment to perform optical testing in flight will enable the Airborne Laser (ABL) Program Office (PO) to avoid a delay in the initiation of a flight test.

Accomplishment

The Flight Dynamics Directorate's Aeromechanics Division successfully performed a CFD analysis, of a large splitter plate mounted on the side of a C-135 aircraft, that provided the ABL PO important pre-flight test data. The Directorate's CFD analysis technique, developed in-house, provided the pressure loads required for the structural analysis (performed by the 4950th Test Wing) and determined the effects on flight characteristics from the addition of the splitter plate.

Background

At the request of the ABL PO, located at Phillips Laboratory, Kirtland AFB, the Flight Dynamics Directorate performed a CFD analysis in support of a planned flight test involving a large splitter plate mounted on the side of a C-135 aircraft. The Directorate modeled the total aircraft (with and without the splitter plate) and analyzed at four test points to determine the pressure loading as well as the incremental effects of adding the splitter plate. Phillips Laboratory engineers designed the splitter plate/optical window configuration to provide an environment where they could perform optical testing without the interference of the turbulent boundary layer created by the aircraft's fuselage. A pylon mounted on the side of the aircraft placed the splitter plate 12 inches away from the fuselage and outside the fuselage boundary layer. By mounting the splitter plate in this fashion, the optical testing only has to contend with a regenerated thin boundary layer that starts at the front of the plate. Concern over the flight characteristics of the modified aircraft as well as concerns about structural loading prompted the wind tunnel and CFD analysis performed by the Directorate. A total of 11 cases were run with the Cray 2 at Kirtland AFB, with each case requiring an average of 6000 iterations to reach acceptable levels of solution convergence. Total computer time required was approximately 260 central processing unit hours. The results of the analysis were provided to the ALB PO within three months, and avoided a delay in the initiation of a flight test.

Wright State Engineering Pre-College Program (Wright STEPP) Helps High School Students

Payoff

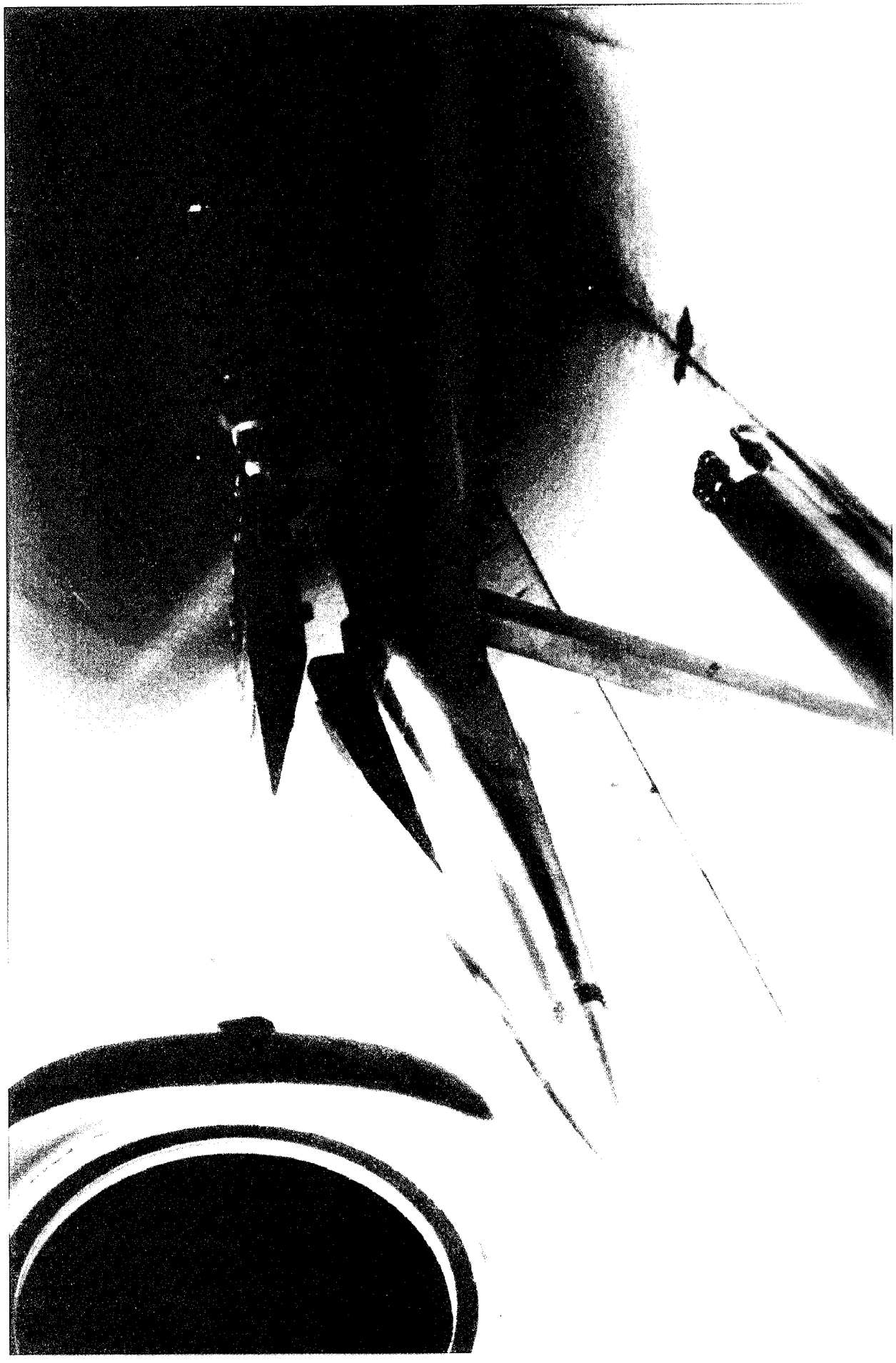
By providing role models and "hands-on" experience to prospective scientists and engineers, the Wright STEPP program helps Dayton-area students make critical career decisions. The involvement of Wright-Patterson Air Force Base (WPAFB) in the program enhances the "good neighbor" image of the Air Force in the local community.

Accomplishment

Along with other WPAFB personnel, Wright Laboratory engineers have donated their time to encourage more than 160 Dayton-area high school students to become interested in obtaining science related college degrees. Seventy percent of the students involved in the program have gone to college to pursue a science degree.

Background

The Wright STEPP program was formulated and established in 1989 by Mr. Clark Beck, a former Wright Laboratory employee, who upon retiring from government service became the Associate Dean of Wright State University's College of Engineering and Computer Sciences. The program brings together volunteer engineers and scientists from the Air Force, teachers from Dayton public schools and instructors from Wright State University to motivate and teach seventh through tenth grade minority group students about disciplines in aerospace, electrical, environmental, human factors, materials and mechanical engineering. To be eligible for the program, each student must be nominated by a science teacher, write an essay and excel in a one-on-one interview. After selection, they participate in a five-week curriculum that includes classes, laboratory time, speakers and field trips to local industry and government offices and laboratories. Mentors from the entire base participate in a "shadow" program. This program introduces pre-eleventh grade students to engineering as a career by inviting the students to work with a scientist for a day in their working environment. Mentors prepare hands-on demonstrations, such as observing thermal behavior of a polymer with a differential scanning calorimeter, following a fiber compression test and examining its failure behavior in an optical microscope and looking at a part under the scanning electron microscope to determine how it broke.



Separation Aerodynamic Characteristics for Two-Stage-To-Orbit (TSTO) Reusable Space Launch System Defined

Payoff

The experimental data base acquired using the Captive Trajectory System (CTS) shown left, provides a unique opportunity to validate the stage separation aerodynamic characteristics for a promising class of TSTO space launch concepts. The availability of "generic" test data also affords an excellent opportunity to expand Computational Fluid Dynamics (CFD) validation to multi-body stage separation effects from nested configurations (i.e., one vehicle contained within the mold lines of another).

Accomplishment

Under an experimental program performed jointly by the Flight Dynamics Directorate's Aeromechanics Division and the Arnold Engineering Development Center (AEDC), the separation aerodynamics characteristics for a technically feasible, two-stage-to-orbit reusable space launch system were defined. Test results showed that the separation of the two similarly sized vehicles from a nested configuration produced no significant or uncontrollable effects on either vehicle at Mach 8.

Background

The Aeromechanics Division has an ongoing program to evaluate solutions to Air Force requirements for ready and reliable access to space. A part of this program has been to propose and define multi-stage, fully reusable launch concepts. Key elements have included the application of near-term technologies to ensure success oriented design concepts, with horizontal take-off and landing for military flexibility. Horizontal take-off and landing drives the stage mating requirements and frequently suggest partial or fully nested staging approaches which have the advantage of superior aerodynamic characteristics, easier ground handling and logistics, and more affordable compact design integration solutions. Unfortunately, little experimental data on the stage separation characteristics for this class of vehicles exists. (Although considerable experimental data was acquired during the initial Space Transportation System studies, it was generally limited to stacked or "piggyback" type configurations). Contact with various contractor and NASA agencies has indicated considerable interest, but attempts to develop joint programs were not successful due primarily to experimental facility limitations. The most obvious facility choices were those at the Air Force's AEDC. However, there was a major problem with the high test peculiar cost associated with the installation of the CTS required for the test program. Through the cooperation of AEDC personnel, the test program was able to be scheduled at a time when the CTS was already installed (i.e., at another users expense). Such an opportunity occurred in early November 1993, when the stage separation study was completed in the Von Karman Tunnel B Facility.

New Injection Molding Process for Transparencies Offers Many Advantages

Payoff

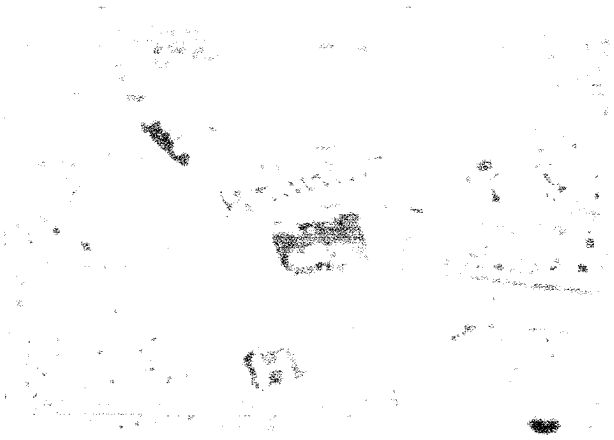
Low pressure, thick-wall injection molding will enable production of very low cost (production costs could drop from $30,000 per unit to as low as $4,000) optically precise, quick change transparencies for both manned and unmanned flight vehicles. When the directly formed, frameless transparencies are fully integrated into the Air Force, the total savings in cost of ownership will reach $500 million by the year 2015.

Accomplishment

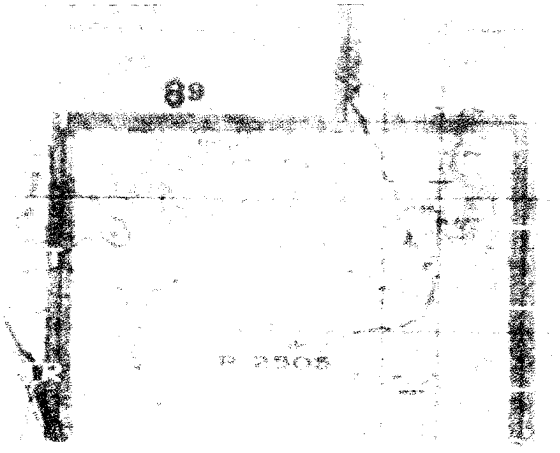
Under a program sponsored by the Flight Dynamics Directorate's Vehicle Subsystems Division, a new, less expensive process has been developed that simply molds canopies out of polycarbonate with aluminum inserts for attachment. When compared with current copies, the frameless units are stronger and more durable, superior in optical quality, less costly and reduce manufacturing time from days to less than an hour.

Background

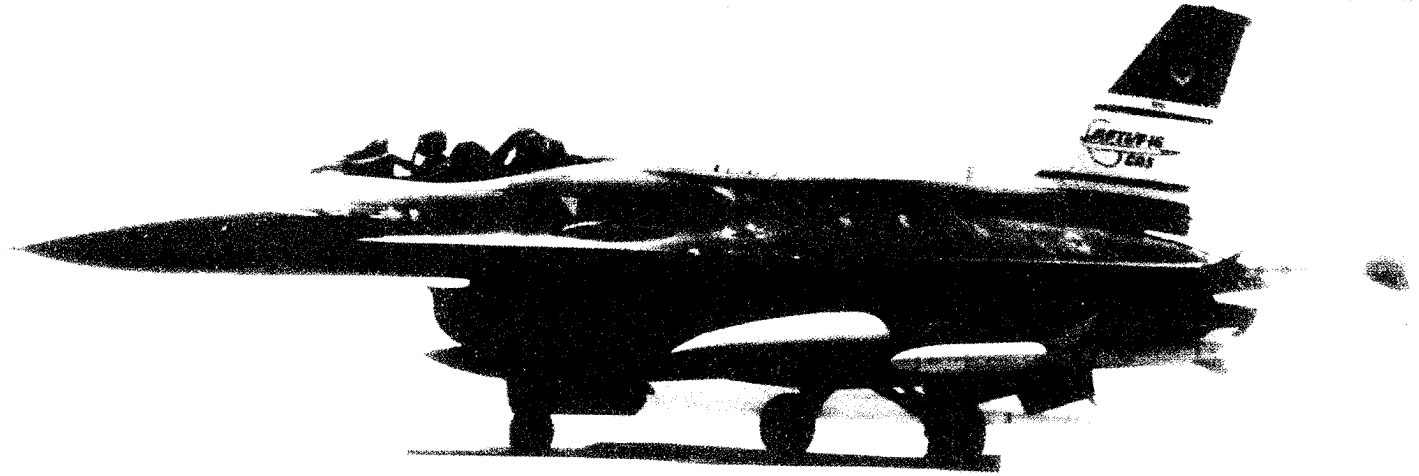
In 1984, the Vehicle Subsystems Division began a program to demonstrate that forming aircraft transparencies (canopies and windshields) directly from molten plastic resin was possible. The current method consists of bending extruded and laminated plastic sheets, machining the edges and fastening the transparent material to a frame. The new technique makes canopies by injecting molten plastic resin into a mold (which produces a transparency in its final shape in only one step), thus bypassing the complicated, time-consuming and expensive steps necessary in the current method. The injection molding process permits accurate control of thickness variations resulting in precise, consistent optics. Forward-facing areas can be made as thick as 0.75 inch to better resist bird impact (a 500 knot birdstrike resistance against a 4 pound bird for a 0.75 inch thick cross section has been demonstrated) and other areas can be made thinner to minimize weight. To demonstrate complete feasibility of this process, full scale injection molding was accomplished. A confirmation frameless transparency, roughly the size of an F-15 windshield, was designed and over 140 were molded during an 11 day period. Lockheed's Fort Worth Division acted as the prime contractor for fabrication and molding tasks. Civilian potential use of this technology includes a host of thick walled, transparent and non-transparent products with embedded hardware such as automotive body panels, basketball backboards and computer cabinets.



"F" COCKPIT THREAT IMAGE VIA SATELLITE



"F" COCKPIT TARGET LOCATION ON DIGITAL MAP



AFTMC-16 HARM LAUNCH

HARM IMPACT ON TARGET

Advanced Fighter Technology Integration (AFTI)/F-16 Talon Sword HARM Demonstration

Payoff

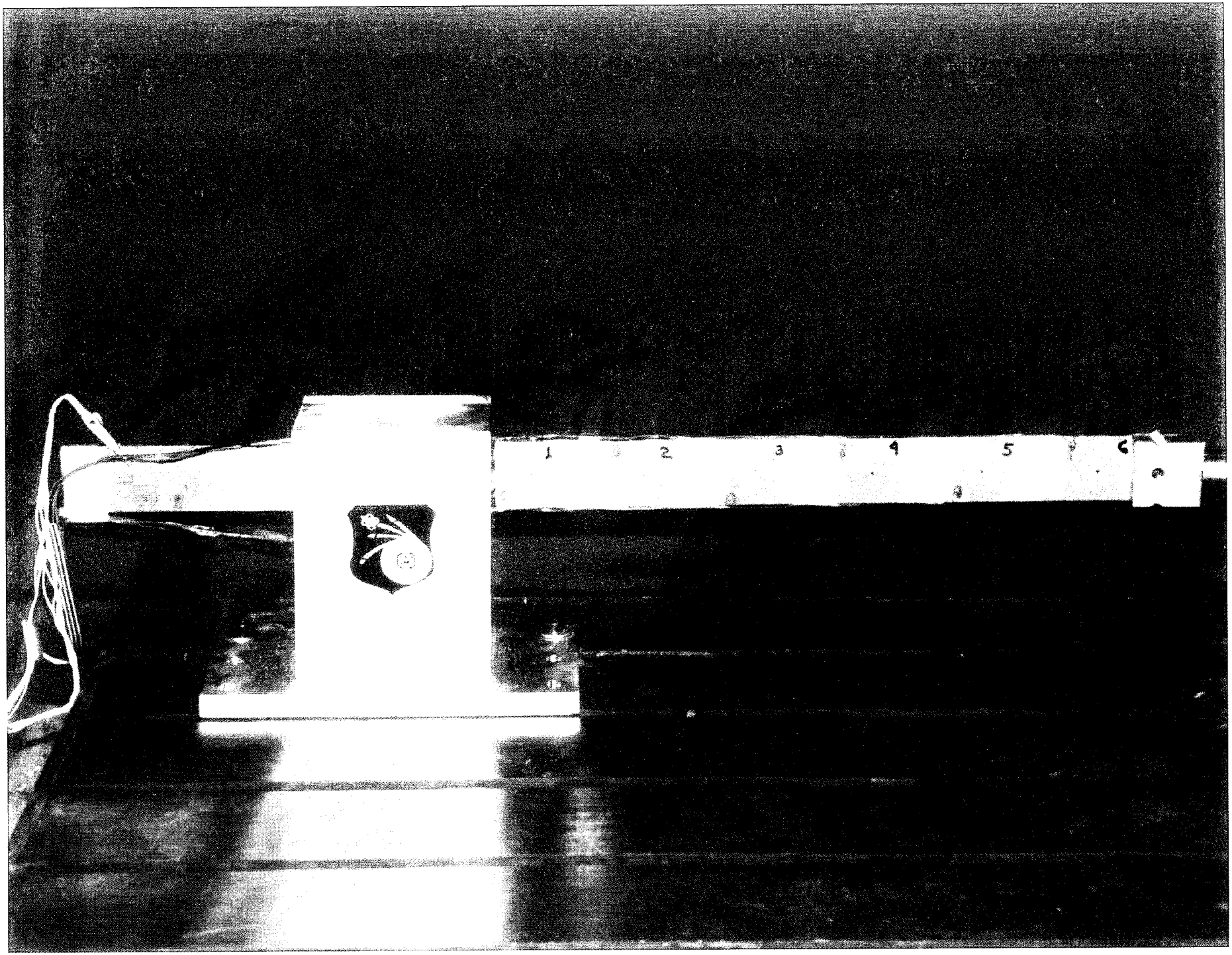
The Talon Sword Program supports a Department of Defense need identified after Desert Storm to seek and destroy mobile targets. The ability to receive off-board threat and target intelligence information real-time, and in the cockpit, permits an attack aircraft to update information relevant to a mission as it is being performed. The data can be used for threat avoidance, situational awareness, and/or to cue employment of the weapon.

Accomplishment

Through the combined efforts of the Flight Dynamics Directorate's Flight Control Division and the Talon Sword Program Office, the AFTI/F-16 demonstrated the use of off-board threat imagery and target location data, which was received real-time via satellite, during a Suppression of Enemy Air Defense (SEAD) mission. The AFTI/F-16 launched an AGM-88 High Speed Anti-Radiation Missile (HARM) against a target location determined with off-board intelligence data. The accuracy of the target location data was illustrated by a direct hit on the target which was non-line-of-sight to the aircraft. The threat imagery was received and displayed to the pilot to improve his situational awareness of the threat environment.

Background

The Air Force Space Command's Talon Sword Program Office has been demonstrating the capability to send intelligence information from a national source to an attack aircraft, real-time, via satellite, using an asynchronous transfer mode format which takes advantage of the "information highway" without jeopardizing mission security. The combat aircraft then uses the data for threat avoidance, situational awareness, and/or to cue employment of the weapon. On 19 May 1994, the AFTI/F-16 flight tested this capability at the Naval Weapons Center, China Lake CA, and marked three aviation firsts: the first time target and threat information (text and imagery) was provided real-time to the attacking aircraft conducting a live fire SEAD mission; the first time for Navy and Air Force interoperability during a SEAD mission; and the first AGM-88 HARM delivery by the AFTI/F-16. The mission scenario entailed national systems sensor data being collected and transmitted from Washington DC, via satellite to a Navy EA-6B while it was flying a KC-135 refueling formation with the AFTI/F-16. The crew of the EA-6B correlated target information sent from Washington, and then transmitted it to the AFTI/F-16 to prepare for a HARM attack. The EA-6B also relayed imagery of a nearby threat to be avoided which AFTI displayed in the cockpit. The mission culminated with AFTI breaking away from the EA-6B and engaging the target with the AGM-88 HARM.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Self-Tuning Piezoelectric Absorber Reduces Vibration Energy

Payoff

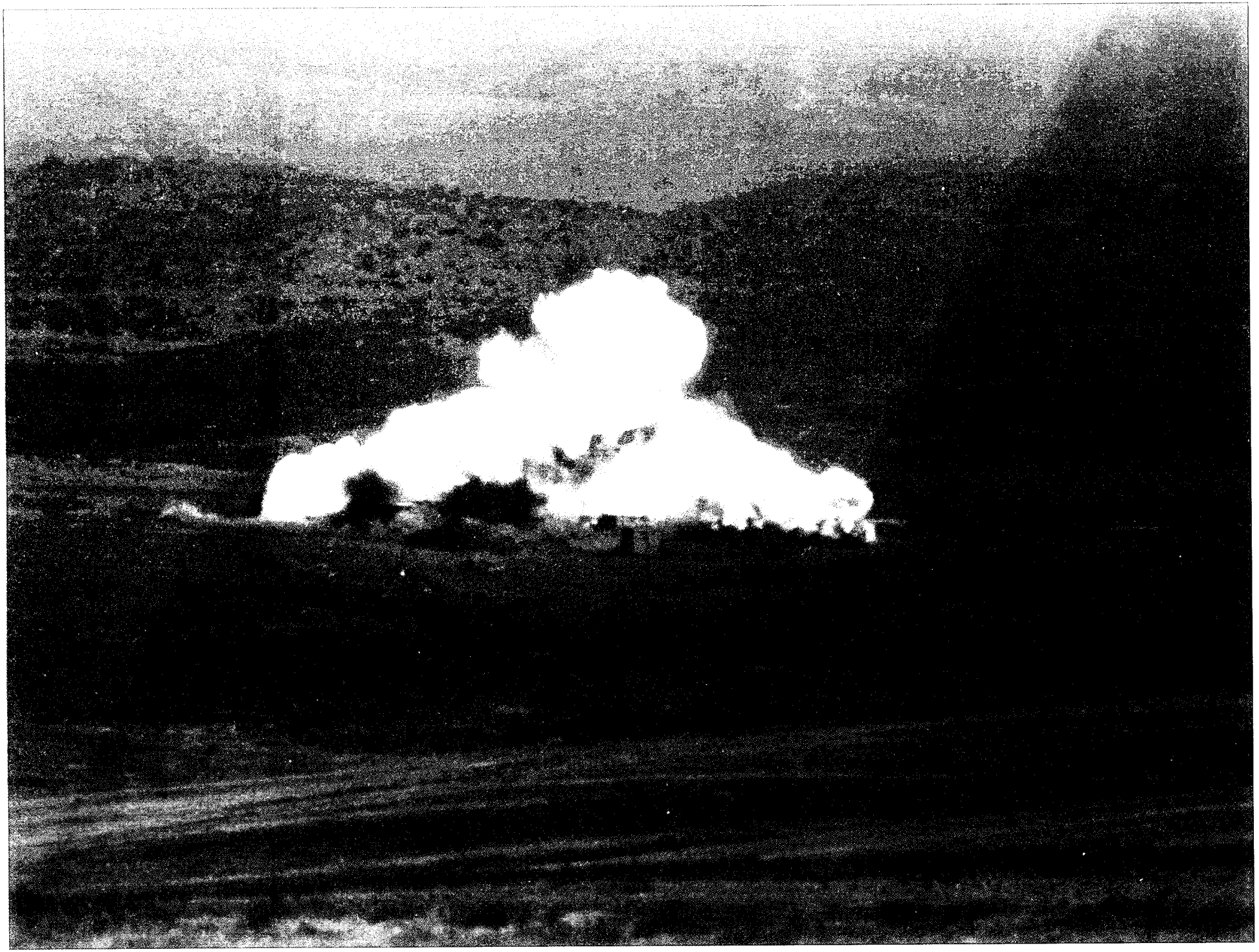
Piezoelectric absorbers, bonded to a test aluminum cantilever beam, provide a passive means of attenuating vibration in metal structures for varying operating conditions. Attenuation of vibration leads to attenuation of stress and strain on the panel structure, thereby increasing the usable lifetime of a structure. Savings can be realized by reducing the number of required repairs, reducing the life cycle cost of the aircraft and keeping aircraft out of depots and flying.

Accomplishment

The Flight Dynamics Directorate's Structures Division has developed analytical modeling techniques to design a multi-mode vibration absorber from a single piezoelectric element and has designed, fabricated and tested the first-ever self-tuning piezoelectric vibration absorber. In laboratory tests on cantilever beams and panel structures, the absorber has been shown to attenuate peak vibration response by 18 decibels, dissipating approximately 80% of the energy in a vibration mode. The self-tuning absorber was able to find a mode with an unknown resonant frequency and track that mode as its frequency abruptly changed. This adaptability does not exist in conventional damping treatments.

Background

Piezoelectric materials are used for vibration control because they have the unique ability to transform electrical energy to mechanical energy and vice versa; they strain when an electrical voltage is applied and produce an electrical voltage when strained. When a piezoelectric material is bonded to a host structure, the piezoelectric strains produce an electric field as the host structure vibrates. An electrical shunt dissipates the electrical energy, thereby dissipating the mechanical vibration energy. The piezoelectric absorber, like a mechanical absorber, has to be tuned to a particular resonance to be effective. A self-tuning absorber uses a controller to keep it tuned to the resonance. The controller is designed for simplicity to increase or decrease the electrical resonance of the absorber. In laboratory tests, abrupt changes in the system parameters were introduced to determine if the absorber could adapt. When a mass was added to the structure to reduce the modal frequency by 25%, the absorber demonstrated that it could retune.



Epoxied Carbon Fiber Composite Sheets Strengthen Concrete Structures

Payoff

An Israeli personnel concrete shelter, reinforced with carbon fiber composite sheets, withstood extremely high pressures from a close proximity detonation that would have caused catastrophic failure to a conventionally reinforced shelter. The field application method for reinforcing concrete walls, developed by the Flight Dynamics Directorate, will facilitate the development of hardening techniques to increase personnel and air base system survivability against high pressure explosions.

Accomplishment

In response to a request from the Israeli Home Front Command and Civil Defense Force, the Flight Dynamics Directorate's Airbase Survivability Section, located at Tyndall AFB, FL, developed a field application for applying epoxied carbon fiber composite sheets to existing concrete structures to increase the flexural and tensile strength of unreinforced and reinforced concrete walls and columns. Static tests on reinforced concrete beams resulted in a 50% increase in load carrying capability.

Background

During the Gulf War, communities in Israel suffered severe damage caused by Iraq's SCUD missiles. Although Israeli homes and apartments were equipped with shelters, they provided little protection against the airblast pressures caused by nearby detonations. A test program was initiated by the Directorate with the goal of providing the Israeli Civil Defense with carbon fiber reinforced walls capable of surviving a full scale detonation at close standoff distances. The Israeli Home Front Command and Civil Defense Force fully supported the project and provided two structures to visually record the damage caused by the detonation of a bomb at a specified standoff distance. The test was conducted in Israel and the structure remained intact with no spalling of interior walls, even though major stress cracks appeared on the exterior wall facing the detonation.

Acronym List

Acronym	Definition
3-D	3-Dimensional
ABL	Airborne Laser
ACC	Air Combat Command
ADAMS	A Digital Avionics Methodology Schema
ADF	Automatic Direction Finding
AEDC	Arnold Engineering Development Center
AFB	Air Force Base
AFOSR	Air Force Office of Scientific Research
AFTI	Advanced Fighter Technology Integration
AIAA	American Institute of Aeronautics and Astronautics
AlAs	Aluminum Arsenide
ALG	Autonomous Landing Guidance
AMPSE	Advanced Multi-Purpose Support Environment
ARPA	Advanced Research Projects Agency
ASARG	Autonomous Synthetic Aperture Radar Guidance
ASD	Atmospheric Sciences Division
ASTM	American Society for Testing and Materials
AT&T	American Telegraph and Telephone
ATEGG	Advanced Turbine Engine Gas Generator
ATF	Advanced Tactical Fighter
ATLAS	Advanced Technology LADAR Seeker
ATMCS	Advanced Tooling Manufacture for Composite Structures
ATMI	Advanced Technology Materials Incorporated
AVID	Automatic Vibration and Diagnostic
CAD	Computer-Aided Design
CAHP	Commercial Aircraft Hardening Program
CFD	Computational Fluid Dynamics
CO	Carbon Monoxide
COMET	F-16 Common Modular Environment
CRDA	Cooperative Research and Development Agreement
CRWG	Computer Resources Working Group
CSI	Crystal Specialties International
cSt	CentiStoke
CT	Computed Tomography
CTAD	Computed Tomography Applications Demonstration
CTS	Captive Trajectory System
CVI	Chemical Vapor Infiltration
DOD	Department of Defense
DSD	Detonation Shock Dynamics
ECS	Environmental Control System
EFOV	Expanded Field of View
FAA	Federal Aviation Administration
FCVI	Forced Chemical Vapor Infiltration
FLIR	Forward Looking Infrared
GaAs	Gallium Arsenide
GigaHz	Giga Hertz
GPS	Global Positioning System
HARM	High Speed Anti-Radiation Missile
HIDEC	Highly Integrated Digital Electronic Control
HRRTR	High Resolution Real-Time Radiography
HUD	Heads-Up Display
ICECS	Integrated Closed Environmental Control System
ICVI	Isothermal Chemical Vapor Infiltration
IHPTET	Integrated High Performance Turbine Engine Technology
IMMS	Integrated Materials Management System
IMU	Inertial Measurement Unit
INS	Inertial Navigation System
ITS	Intelligent Tutor System
KHILS	Kinetic Kill Vehicle Hardware-In-The-Loop Simulator
KTP	Potassium Titanyl Phosphate
LADAR	Laser Radar
LCC	Life Cycle Cost
LED	Light Emitting Diodes
MANTECH	Manufacturing Technology
MATV	Multi-Axis Thrust Vectoring
MCS	Manned Combat Station
MEA	More Electric Aircraft
MESFET	Metal Semiconductor Field Effect Transistor
MHz	Mega Hertz
MITS	Mobile Inertial Test System
MMIC	Monolithic Microwave Integrated Circuits
MMWR	Millimeter Wave Imaging Radar

(continued on next page...)

Acronym List

Acronym	Definition
MODGRO	Fatigue Crack Growth Prediction Software
MTC	Modern Technologies Corporation
MTI	Mechanical Technology Incorporated
NASA	National Aeronautics and Space Administration
NASTRAN	NASA Structural Analysis
NCI	National Cancer Institute
nm	Nanometers
NOx	Nitrogen Oxides
NTESD	Non-Thermal Silent Electric Discharge
NVG	Night Vision Goggles
OC-ALC	Oklahoma City Air Logistics Center
OCD	Operational Concept Demonstration
ODC	Ozone Depleting Chemical
OFP	Operational Flight Program
OO-ALC	Ogden Air Logistics Center
OPO	Optical Parametric Oscillators
PCA	Propulsion Controlled Aircraft
PCCADS	Panoramic Cockpit Controls and Displays System
PERFECT	Peroxide in Fuel Estimation and Concentration Test
PLD	Pulsed Laser Deposition
PM	Program Manager
PO	Program Office
RCS	Radar Cross Section
RF	Radio Frequency
RFC	Retirement For Cause
RTA	Rubidium Titanyl Arsenate
SA-ALC	Sacramento Air Logistics Center
SAR	Synthetic Aperture Radar
SBIR	Small Business Innovation Research
SEAD	Suppression of Enemy Air Defense
SEEDD	Single and Dual-Bank Detection Discrimination and Tracking
SHaRRP	Sensor Handoff, Discrimination Target Selection
SiC	Silicon Carbide
SIMOX	Separation by Implementation of Oxygen
SIT	System Level Test
SMT	Subminiature Telemetry
SOI	Silicon-on-Insulator
SOS	Silicon-on-Sapphire
SPO	System Program Office
SQL	Standard Query Language
SRL	Systems Research Laboratory
TCE	Trichloroethylene
TRP	Technology Reinvestment Program
TSC	The Scholar's Companion
TSTO	Two-Stage-to-Orbit
UCLA	University of California - Los Angeles
UHF	Ultra High Frequency
USAF	United States Air Force
UUT	Unit Under Test
VDS	Virtual Dome Simulation
VHF	Very High Frequency
VISTA	Variable-Stability Inflight Simulator Test Aircraft
WL	Wright Laboratory
WPAFB	Wright-Patterson Air Force Base
WR-ALC	Warner Robins Air Logistics Center
Wright STEPP	Wright State Engineering Pre-College Program

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